Transactions of American Society for Steel Treating

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4600 Prospect Avenue

TRANSACTIONS

of the

American Society for Steel Treating

Vol. II Cleveland, May 1922 No. 8

PITTSBURGH SECTIONAL MEETING ARRANGEMENTS

THE WILLIAM PENN Hotel will be the headquarters for the Pittsburgh Sectional meeting to be held May 25 to 27. Arrangements have been made by the committees in charge, whereby a limited number of rooms will be available at the hotel. Due to the fact that there is another large convention being held in Pittsburgh at this same time it is highly important that all those who are planning on attending this meeting, make their reservations without delay. It is suggested that requests for reservations be sent either to the hotel or to W. A. Buechner, 501 Manufacturers building, Pittsburgh, or D. H. Horne, Standard Alloys Co., Pittsburgh.

The members of the Pittsburgh Chapter are bending every effort to make this meeting an unqualified success. All of the arrangements have been made for carrying through this meeting. The program of papers, plant visitation and entertainment clearly indicate that the Pittsburgh meeting will not be second to the New York Sectional meeting held in March.

Four of the papers to be presented are published in this issue of the TRANSACTIONS. Discussion of these papers is invited and it is hoped that good lively comment will follow each of the papers presented. If for any reason a member is unable to attend the meeting, a written discussion of any or all of the papers would be appreciated by the committee in charge, and can be addressed to W. J. Merten, 416 Lang avenue, Pittsburgh.

The program for the meeting is as follows:

Thursday, May 25

11 a. m. to 1 p. m.—Auditorium, Bureau of Mines.

Informal gathering and registration of out-of-town members and guests. In charge of W. H. Eisenman, National Secretary, assisted by Messrs. Horne, Phillips, and Cook.

1:30 p. m. to 4:30 p. m.—Auditorium, Bureau of Mines.

Address of welcome, by Chairman of Pittsburgh Chapter.
Response by National President, F. P. Gilligan.
Technical Session presided over by Past Chairman of Pittsburgh Chapter.
Papers by:

Professor McIntosh, Carnegie Institute of Technology, "Fiber in Steel and Iron".
W. B. Crowe, metallurgist, Carnegie Steel Company, "Mass Influence on Heat Treating".
John M. Lessells, Westinghouse Electric & Mfg. Co., East Pittsburgh, "Impact Tests".

7:00 p. m.—University Club—Banquet.

Addresses and music relayed over KDKA, Westinghouse Radiophone station.
Toastmaster—G. H. Neilson, president, Braeburn Steel Co. and past president,

Western Pennsylvania Engineers Society.
Speakers—Doctor Bowman, chancellor, University of Pittsburgh; Dr. J. A. Mathews, president, Crucible Steel Co. of America; Prof. F. Crabtree, chairman, American Institute of Mining and Metallurgical Engineers, Pittsburgh Division; and vice chairman, Western Pennsylvania Engineers Society. "History of Metallography and Heat Treatment of Iron and Steel".
Followed by impromptu speeches by guests representing prominent local industries.
Music by Greater Pittsburgh Quartet.

Friday, May 26

9:00 a. m. to 12:00 m.
Assembly at Schenley Hotel to visit steel mills and manufacturing plants.
1:30 p. m. to 4:30 p. m.—Auditorium, Bureau of Mines.
Technical Session—Presided over by Chairman of visiting section.
Papers by:
A. M. Cox, Pres. and Treasurer, Pittsburgh Commercial Heat Treating Co., Pittsburgh.
J. A. Succop, Heppenstall Forge & Knife Co., "The Importance of Properly Heated and Cooling Steel".
Mr. Smith, Union Spring & Manufacturing Co., New Kensington, Pa., "Manufacture of Springs".
Mr. Marcus A. Grossman, Electric Alloy Steel Co., Youngstown, O., "Shrinkage of High Speed Steels".
7:30 p. m. to 11:00 p. m.—Auditorium and Cafeteria, Bureau of Mines.
Open-Hearth Furnace Film—American Rolling Mill Company.
Smoker, in charge of Entertainment Committee.

Saturday, May 27

10.00 a. m.—Auditorium, Bureau of Mines.
Directors meeting.
8:00 p. m.
Carnegie Institute of Technology, School of Dramatic Arts. Little Theater play by School of Dramatic Arts.

HOTEL RATES FOR PITTSBURGH MEETING

BELOW are given the hotel room rates for the William Penn Hotel, which has been selected as the headquarters during the Pittsburgh Sectional meeting, May 25 to 27. The rates are as follows:

Court rooms, single with shower bath	$5.00 per day
Court rooms, single with tub bath	$5.00—$5.50 per day
Court rooms, double with shower bath	$6.50 per day
Court rooms, double with tub bath	$7.00 per day
Court rooms, double with twin beds, bath	$7.50 per day
Outside rooms, single with tub bath	$6.00—$7.00 per day
Outside rooms, double with tub bath	$8.00—$9.00 per day
Outside Rooms, double with twin beds, bath	$9.00—$10.00—$11.00 per day

NEW YORK SECTIONAL MEETING IS GREAT SUCCESS

NO DOUBT can exist as to the complete success of the New York Sectional Meeting which was held at the Hotel McAlpine, Friday, March 3. This was the Society's first effort to hold a sectional meeting and upon its success or failure depended more or less the policy of the Society in future meetings of the same kind. The registration totaled approximately 200 with 14 eastern and New England chapters being represented. The purpose of the Society is to hold such meetings in different portions of the country which would serve to bring the membership of

that locality into closer touch with one another and to afford to those that had not attended the annual Conventions some of the advantages that accrue from a general meeting of the Society.

The opening session was held on Friday afternoon by an address of welcome by George L. Norris, chairman of the New York Chapter. Following this the chairmanship of the meeting was turned over to Irving H. Cowdrey, chairman of the Boston Chapter, who introduced the five speakers. The technical papers presented and their authors were as follows: "New Development on the Influence of Mass in Heat Treatment," by E. J. Janitzky, metallurgical engineer, Illinois Steel Co., South Chicago, Ill.; "Calite—A New Heat Resisting Alloy," by G. R. Brophy, metallurgist, research laboratory, General Electric Co., Schenectady, N. Y.; "Stainless Steel in Cutlery Use," by R. G. Hall, research engineer, R. Wallace & Sons Mfg. Co., Wallingford, Conn.; "Cold Headed Bolts—Their Metallography and Heat Treatment," by V. E. Hillman, metallurgist, Crompton & Knowles Loom Works, Worcester, Mass.; and "The Magnetic Testing of Small Case Hardened Chain," by A. V. De Forest, metallurgist, American Chain Co., Bridgeport, Conn. The papers of Mr. Janitzky, Mr. Brophy, Mr. Hillman and Mr. De Forest appeared in the February issue of TRANSACTIONS while the paper of Mr. Hall together with the discussions for all the papers were published in April. Mr. De Forest gave an actual demonstration of the magnetic chain testing process showing the results which could be obtained regarding the proper care required for automobile skid chains.

In the evening about 100 attended the informal dinner at the Yates Hotel, where the menu consisted of water-quenched celery, oil-tempered olives, case-hardened tenderloin beef, sorbitic peas, over-heated potatoes, etc. The second technical session was held Friday evening at the Hotel McAlpine with A. W. F. Green, chairman of the Philadelphia Chapter as the chairman. For a few minutes the meeting was turned over to the National President F. P. Gilligan, who presented an engraved certificate of honorary membership to Dr. John A. Mathews, president of the Crucible Steel Co. of America. Doctor Mathews was elected to this honor by the Board of Directors meeting at the Indianapolis Convention. The recipient is widely known for his work in developing and heat treating alloy steels as well as his pioneer work in connection with the manufacture of electric steel. Doctor Mathews accepted the certificate with a brief speech of appreciation.

The first technical paper, "Perfecting a Drop Forging" was presented by J. H. G. Williams, assistant works manager, Billings & Spencer, Hartford, Conn. This paper appeared in full in the February issue of TRANSACTIONS but the discussion was in the April issue. At the conclusion of Mr. Williams' paper, the meeting was turned over to National Secretary W. H. Eisenman, who reviewed extensively the events leading to the amalgamation of the two heat treating societies into the present organization and stressed particularly the leading part which Lt. Col. A. E. White had played, later becoming the first National President of the Society. Then calling Colonel White to the front, Mr. Eisenman, on behalf of the entire society presented him with a mahogany chest of sterling silverware.

In part Mr. Eisenman's words were as follows: "Colonel White, this chest of sterling is presented to you for a particular reason. Sterling

—because it represents the character of the recipient, sterling because it represents the foundation work which he has so well laid and which is shown in the progress and success our Society has made. Colonel, I present you this key, and may it unlock this chest and give to you as much satisfaction as it gives to us pleasure in the presentation of it, and may you consider it as a mark of our undying esteem and high regard for you and your work." Colonel White was taken entirely by surprise. With a few brief remarks he assured the Society of his heartfelt appreciation.

The final paper on the program was "The Manufacture of Steel", by B. H. De Long, metallurgist, Carpenter Steel Co., Reading, Pa. This paper was highly illustrated and showed the equipment for making high grade tool steels by the open-hearth, electric and crucible processes.

BOARD OF DIRECTORS NAMES EDITOR FOR TRANSACTIONS

Ray T. Bayless

IT IS with pleasure that the Board of Directors is able to announce the appointment of Ray T. Bayless as full time editor of the TRANSACTIONS. The Board has been considering this matter for some time and it now feels that the Society requires and can support the services of an editor devoting his entire time to the publication. It is the aim and purpose of the national officers to have the TRANSACTIONS stand out prominently as an educational publication and with this in view, a definite constructive program will be developed that will serve the needs respectively of the practical steel treater and forger, the technically trained man and the executive who exercises general oversight and direction of both practical and technical groups. It is expected that the editor eventually will be brought in close contact with the officers and outstanding members of the various chapters of the Society and that he will be able to correlate some of the educational activities of the various chapters so that ultimately the TRANSACTIONS will offer a more intensive and continuous program along educational lines than has heretofore been possible.

In extending this work, subjects of interest to the technical member will not be overlooked, but on the other hand it is hoped that it will be possible to establish closer relations with other metallurgical societies in this country and abroad, and to keep our members in intimate touch with developments of interest in the steel treating world at large.

Mr. Bayless graduated from the University of Michigan with the degree of Bachelor of Chemical Engineering. During his university work he specialized in metallurgy and metallography and acted as student assistant during his junior and senior years.

Mr. Bayless was born and raised in Detroit and has had extensive experience in the metallurgical profession. Upon graduation he was assistant analytical chemist with the Michigan Smelting and Refining Co., Detroit, after which he become assistant analytical chemist with the General Motors Co. at its Detroit laboratory.

For about two years Mr. Bayless was assistant chief chemist and metallurgist with the Chalmers Motor Co., being promoted to chief chemist and metallurgist of the Saxon Motor Car Corp., remaining with that company until its plant was destroyed by fire.

During the war, Mr. Bayless was supervisor of tests for the United States Army Ordnance Department, Cleveland district, having supervision of all tests of materials used in the production of ordnance in that district. One hundred direct assistants were under his supervision.

At the close of the war he become associated with the James H. Herron Co., engineers and was in charge of all metallurgical problems having under his supervision the metallographical, physical and heat treatment laboratories.

Mr. Bayless brings to the TRANSACTIONS an extensive knowledge of metallurgy from both the practical and theoretical standpoint and will give his best efforts in making the publication of greater service to the membership.

TREASURER SUBMITS FINANCIAL STATEMENT

THE accompanying report of the auditors shows the history of the financial transactions of The American Society for Steel Treating for the first full year of its operation. Attention is called to the fact, that the total support given the local chapters is not shown by the income and expense statment. This is because during the greater part of the year dues were collected by the chapters who deducted their 35 per cent before remitting to the National Office. The total financial support given the Chapters for the year was $9,700.00

It will be noted that the income and expense shown for the Philadelphia Convention represent deferred collections and expenses which were carried over from the year 1920.

The most favorable time for closing the books of the Society having been found to be Jan. 1, the Finance Committee has designated the calendar year as the fiscal year of the Society, so far as its financial transactions are concerned. The report appears in full on the following page.

Signed

J. V. EMMONS,
Treasurer

AMERICAN SOCIETY FOR STEEL TREATING INCOME AND EXPENSE STATEMENT, YEAR 1921

INCOME

Advertising		$20,147.16	
Membership dues (exclusive of 35 per cent portion retained by chapters)	$21,732.66		
Less refund to local chapters	2,489.91	19,242.75	
Indianapolis convention (1921)	14,549.65		
Less refunds to exhibitors	645.40	13,904.25	
Philadelphia convention (1920)		1,953.72	
Transaction sales		701.07	
Miscellaneous income		622.61	
Interest and discounts		387.52	$56,959.08

EXPENSES

Transactions	17,366.70	
Secretary's office	9,807.62	
President's office	1,941.48	
Treasurer's office	895.00	
Directors' expense	661.57	
National committees	329.42	
Indianapolis convention (1921)	13,697.81	
Philadelphia convention (1920)	1,201.32	
Bad debts	1,614.71	
Miscellaneous expense	849.85	
Discounts allowed	488.36	48,853.84
Excess of income over expenses		8,105.24

BALANCE SHEET

Dec. 31, 1921

ASSETS

Current cash	$1,635.14
Cash and securities held as reserve for dues paid in advance	9,500.00
Accounts receivable	4,202.42
Furniture and fixtures	1,183.34
	$16,520.90

LIABILITIES

Accounts payable			$640.16
Reserve for dues paid in advance			9,500.00
Reserve for past due and doubtful accounts			800.00
Surplus Dec. 31, 1920		$7,958.83	
Excess of income for year		8,105.24	
		$16,064.07	
Less—			
Depreciation furniture and fixtures	$983.33		
Reserve for dues	9,500.00	10,483.33	
Surplus Dec. 31, 1921			5,580.74
			$16,520.90

CERTIFICATE

We have made an audit of the books of account and record of the American Society for Steel Treating and, in our opinion, the above Balance Sheet and Income and Expense Statement correctly present its financial status at Dec. 31, 1921, and a history of its financial transactions for the period under review, basing the income from dues upon cash receipts and other income upon accruals.

Respectfully submitted,

NAU, RUSK & SWEARINGEN,
Certified Public Accountants.

A DISCUSSION OF IMPACT TESTING METHODS AND THE RESULTS OBTAINED

By John M. Lessells

DUE to the advent of the automobile and aircraft engines, and the high working stresses used in service, the heat treatment of steels has become an applied science. The quality of the heat treated product must be determined by recognized and accepted physical tests, and these must be in some measure welcome to the heat treater and the steel manufacturer. If it can be established that some new test shows up characteristics in a heat treated steel which the accepted and more or less conventional tests do not show, then this test should be favorably regarded by all who desire to get the best from their materials. Since the impact test seems to be in this catagory, it is proposed to present a few more or less familiar facts on this method or testing, together with certain conclusions, for consideration and discussion.

It has been said that the impact test is a new one, but this is literally not correct, since it has been used for a considerable time as an acceptance test in certain European specifications; but since it is not generally adopted in this

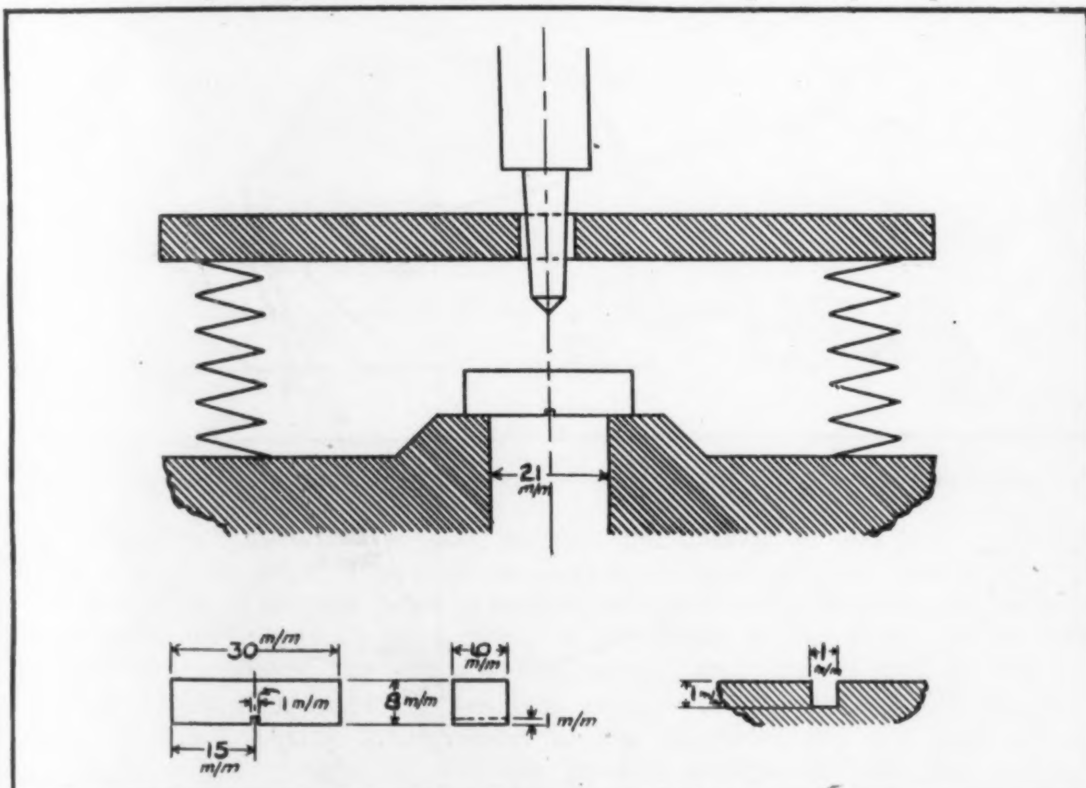


Fig. 1—Arrangement of Fremont impact testing machine with sketch of test specimen shown below

country, it can be so considered. A committee of the American Society for Testing Materials is at present working on some form of test suitable for the United States requirements.

There are numerous forms of impact testing machines, but it is only proposed to review a few of them: namely 1. Fremont, 2. Charpy, 3. Izod,

A paper to be presented at the Pittsburgh Sectional meeting, May 25-27. The author, John M. Lessells, is connected with the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

and 4. Stanton. Each of these machines, named after the inventor, use a notched test specimen. Therefore, these tests might be more aptly called "notched bar tests." The Stanton test is really a repeated impact test although it has been given a place in this discussion.

The Fremont test requires a test specimen which is 30 millimeters long having a cross section of 8 by 10 millimeters. It is notched on the broad side 1 millimeter deep and 1 millimeter wide. The test piece is laid on supports 21 millimeters apart with the notch on the underside and struck a blow with a falling tup midway between the supports. The difference between the energy before and after the fracture gives the amount of energy necessary for fracturing the test specimen. In Fig. 1 is shown a sketch of the arrangement of this machine and a sketch of the test piece employed. The weight of the tup, which falls from a height of 4 meters is 10 or 15 kilograms. It will be noted that a machine of this kind requires considerable height above the floor level, but possesses the advantage of having a high speed of impact.

The Charpy test requires a test specimen which is 55 millimeters long, having a cross section of 10 by 10 millimeters. It is notched in the center

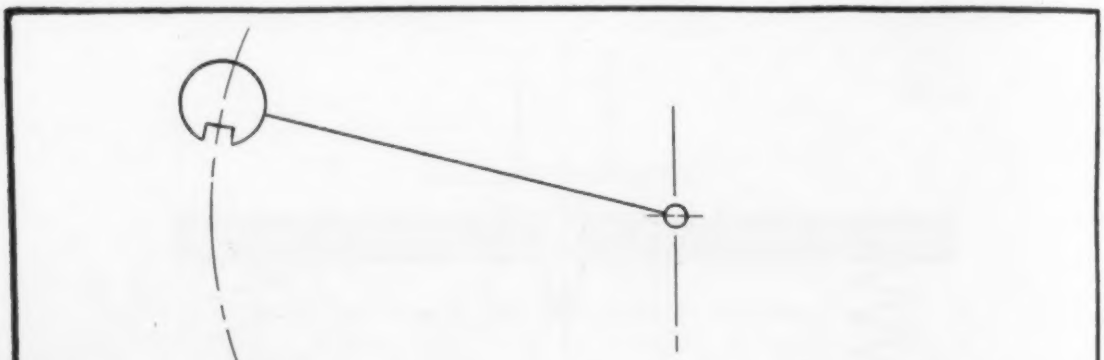


Fig. 2—Arrangement of Charpy impact testing machine with sketch of test specimen shown below

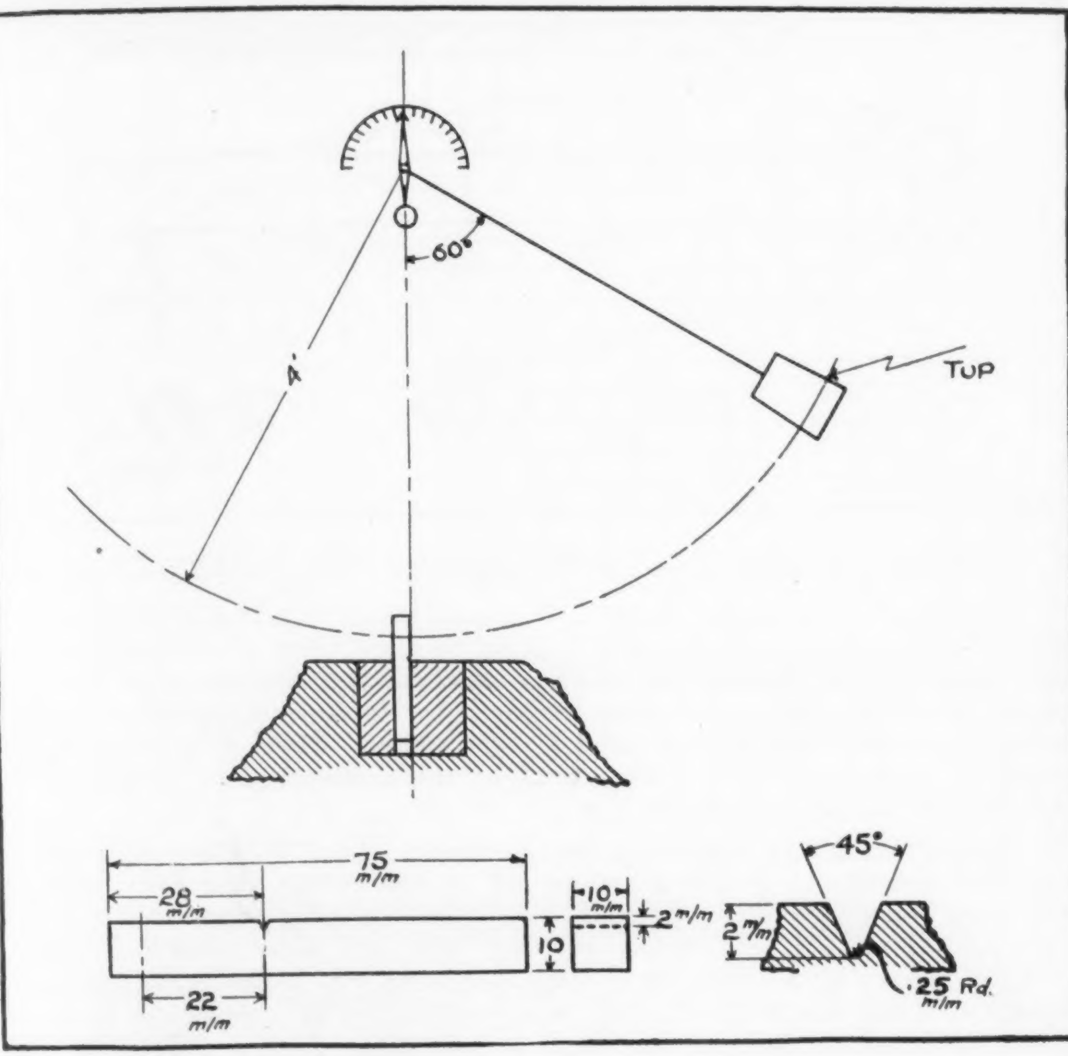


Fig. 3—Arrangement of Izod impact testing machine with sketch of test specimen shown below

by drilling a 1.3-millimeter hole so that the bottom of the hole is 5 millimeters from the edge. The notch is completed by running a 1-millimeter slot into the hole. This test piece is supported horizontally between 40-millimeter abutements and is struck by a swinging pendulum at the middle of its length on the side opposite the notch. The energy absorbed in making the fracture is determined from the residual energy after fracture. In Fig. 2 is shown a diagrammatic arrangement of the machine, and the test specimen employed. The weight of the tup is 32.5 kilograms. It will be noted that the machining of a notch of this nature requires at least two operations to complete it and is probably difficult to reproduce accurately on hard materials. This difficulty of obtaining notch uniformity is, of course, more or less inherent in all impact tests, but is probably more pronounced in this case.

The Izod test requires a test specimen which is 75 millimeters long with a cross section of 10 by 10 millimeters. It has a transverse 45-degree angle, V-shaped notch 2 millimeters deep as shown in Fig. 3; the radius at the root of the notch being 0.25 millimeter. The piece is held vertically in a vise with the lower edge of the notch at the same level as the vise edge

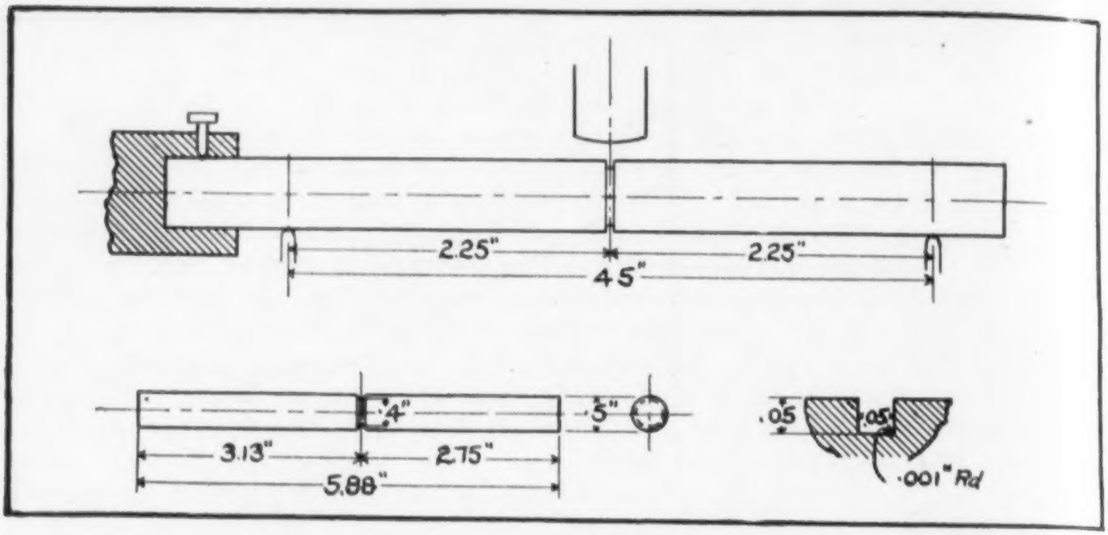


Fig. 4—Arrangement of Stanton repeated impact machine with sketch of test specimen shown below

and is broken by a swinging tup striking the test piece on the notched side but above it. As before, the residual energy deducted from the striking energy gives that energy which was required for fracturing the test piece. This energy is usually indicated on a scale by a pointer which is actuated by the swinging pendulum. The arrangement of the machine and a sketch of the test piece employed is shown in Fig. 3.

The Stanton test requires a test specimen about 6 inches long having a ½-inch diameter. It has a groove cut at the center, 0.05 inch deep and 0.05 inch wide. This test piece is held horizontally in supports 4½ inches apart and is rotated 180 degrees between successive blows which are struck over the groove by a falling tup. The weight of this hammer, or tup, is 4.7 pounds and the height of the fall is adjustable. The number of blows required to fracture the test specimen is recorded. Fig. 4 shows the diagramatic arrangement of this machine, and a sketch of the test piece employed.

It is proposed in the first place to discuss a few of the results obtained from the Izod machine and to confine the remarks to four grades of steel: namely, 1. Low carbon, 2. medium carbon, 3. nickel, and 4. nickel chrome.

In discussing test results, it is felt that curves are more convincing than tabulated figures. Therefore, the various impact characteristics, together with the other well known physical properties, for different grades of steel, are shown in Figs. 5 to 13 inclusive.

Fig. 5 represents a low carbon case-hardening steel plotted on a base of quenching temperature. The increase of impact value in the region of 760 degrees Cent. is quite characteristic of this class of material.

Figs. 6 and 7 show the properties of an oil hardening and an air hardening nickel chrome steel, respectively. These latter curves have been plotted on a base of Brinell hardness; the main features being the similar manner in which impact and reduction of area values and in a less manner, elongation values, respond to heat treatment variation. This response seems to indicate that the impact value has some relation to the structure of the ma-

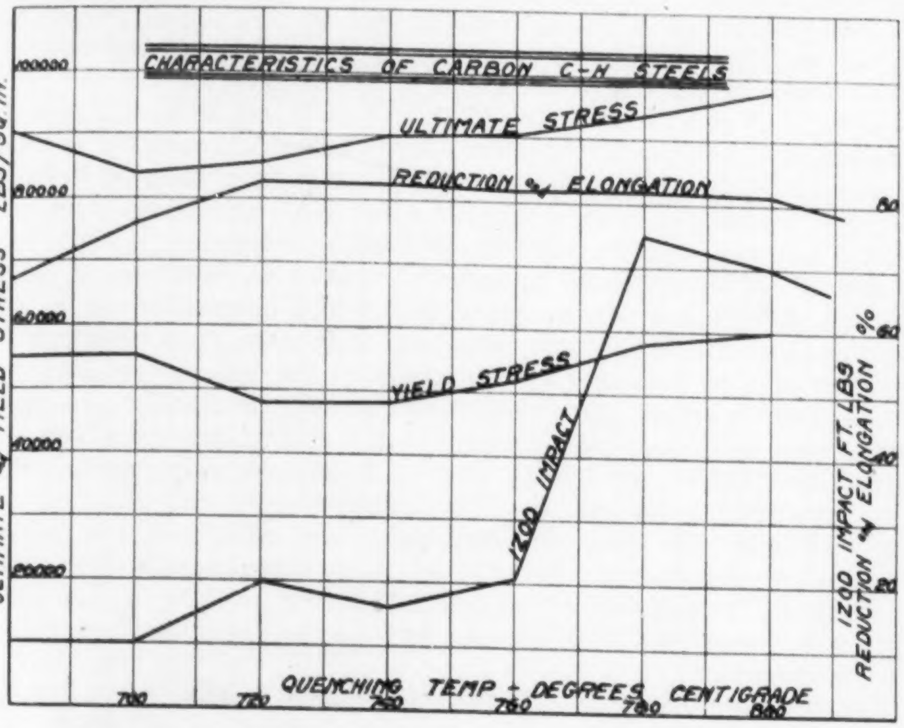


Fig. 5—Physical characteristics of carbon case hardening steels

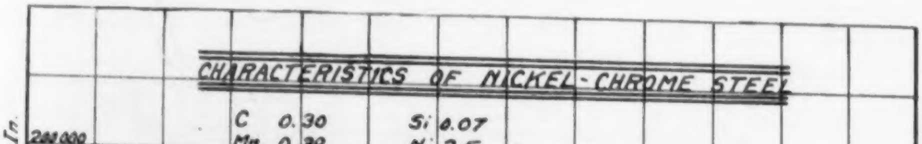


Fig. 6—Physical characteristics of nickel chrome steel

terial. This statement is further confirmed by the rapid increase of impact value as the quenching temperature is increased beyond a certain value, as shown in Fig. 5.

Figs. 8 to 13 represent a family of curves taken from the report of the Steel Research Commission, London, 1920, but confirmed by certain work of the author. In these curves, which are plotted on a base of drawing temperature, the manner in which the reduction of area varies with impact is again very striking. A further point for consideration is obtained from Figs. 9 and 10. The respective analyses of these two steels are approximately alike, provided the small percentage of nickel and chromium can be neglected in steel, Fig. 10. If this is true, then the difference of 30 degrees Cent. in drawing temperature has increased materially the impact values for allowing for observation errors; the other values remain practically constant. This, therefore, leads up to the conclusion that the impact test is a very sensitive one indeed and shows up by its results, when properly interpreted, small variations in thermal treatment.

Figs. 12 and 13 show up strikingly the effect of the addition of chromium to a nickel steel, for assuming that the upper limit of Brinell hardness from the point of view of machining is 320, a comparison of these steels is made in Table 1. A steel of 0.45 per cent carbon is also added for comparison.

It will be seen that although the Izod value in the nickel chrome steel is slightly lower, nevertheless, the benefit derived from the addition of chromium is apparent. Such a material would be suitable for high speed connecting rods where lightness is required. Referring to Fig. 13, it will be noted that the impact value commences to decrease at a drawing temperature of approximately 200 degrees Cent. and reaches a minimum value of 5-foot pounds at a temperature of 350 degrees Cent. It will be observed

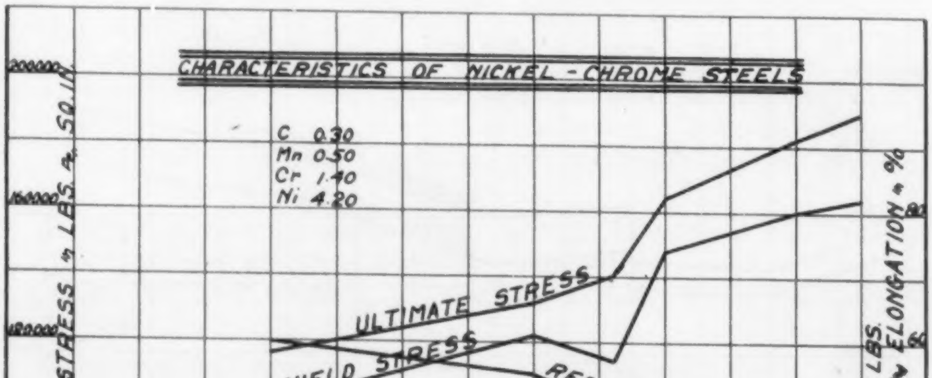


Fig. 7—Physical characteristics of nickel chrome steel

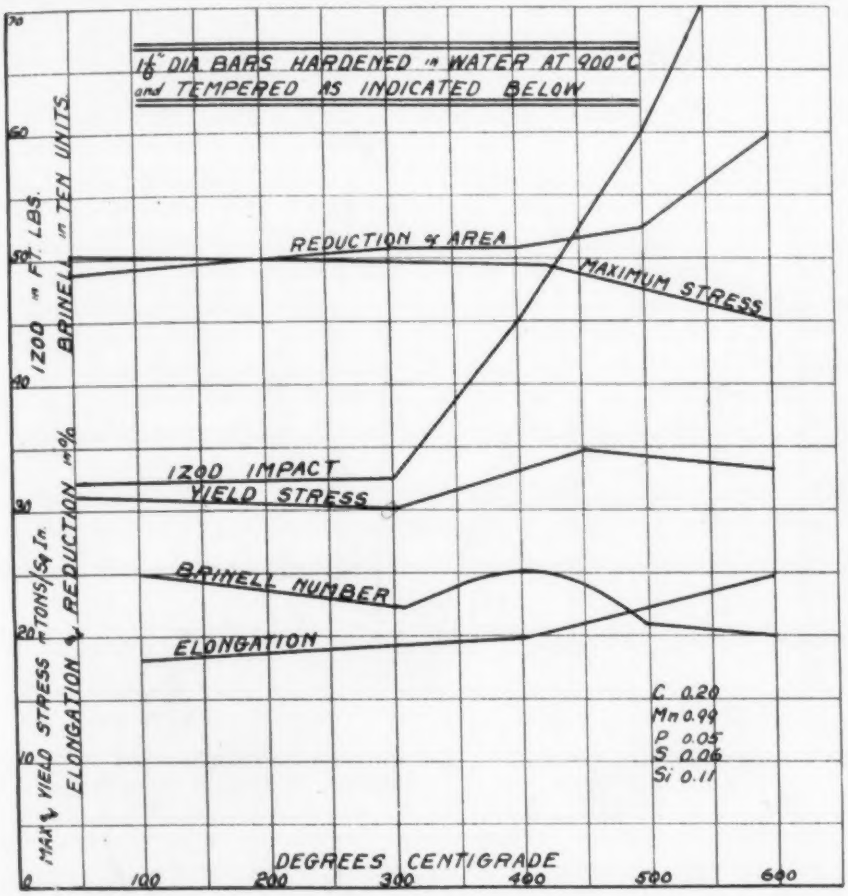


Fig. 8—Physical properties of bars 1⅛ inches in diameter hardened in water at 900 degrees Cent. and tempered as shown

Table I

Effect of Adding Chromium To a Nickel Steel

	Nickel Steel (See Fig. 12)	Nickel Chrome Steel (See Fig.13)	Carbon Steel See Fig. 11)
Brinell hardness	320	320	320
Maximum stress, pounds per square inch	153,000	170,000	145,000
Yield point, pounds per square inch	130,000	153,000	105,000
Elongation, per cent	16	18	13
Reduction of area, per cent	54	56	37
Izod impact, foot pounds	26	22	15

Table II

Physical Properties of Nickel Chrome Steel

Maximum stress pounds per square inch	Yield point pounds per square inch	Elongation per cent	Reduction of area per cent	Izod foot pounds	Brinell No.
Group A					
107,000	86,000	24	66 .	10	240
Group B					
110,000	85,000	25	64	80	240

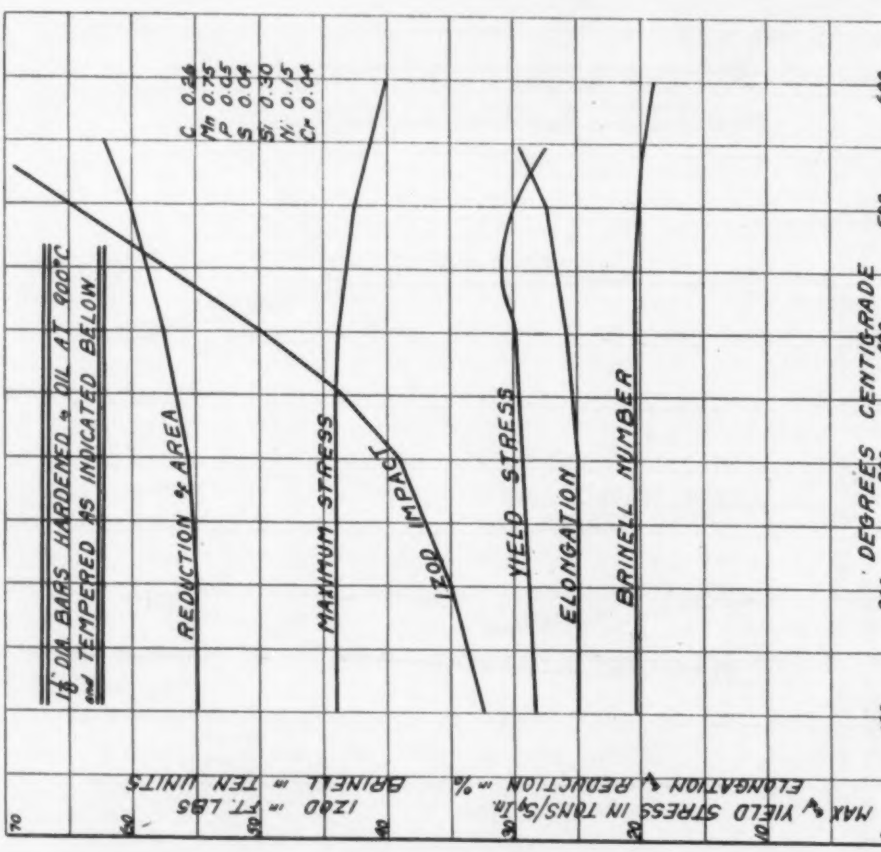


Fig. 10—Physical properties of 1⅛-inch diameter bars hardened in oil at 900 degrees Cent. and tempered as shown

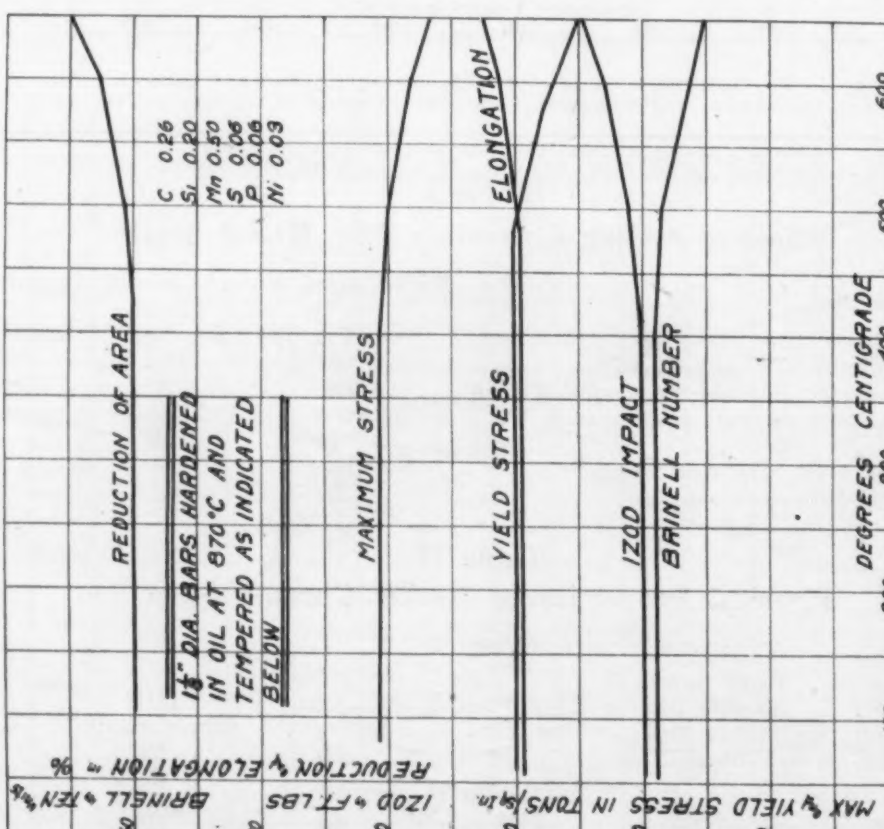


Fig. 9—Physical properties of 1⅛-inch diameter bars hardened in oil at 870 degrees Cent. and tempered as shown

also that the other physical properties show a steady change over this temperature range. This drop in impact value is known as temper brittleness and is a characteristic, more or less, of nickel chrome steels when slowly cooled through this range of temperature. It can be eliminated by rapidly cooling through this range by quenching from the drawing temperature. Therefore, once more is it apparent that the impact test has an intrinsic value, and in this case shows up undesirable characteristics which are not revealed by the tensile test. The following numerical values are given on this important phase of this subject. A steel of the analysis carbon 0.26, nickel 3.5, chromium 0.84, sulphur 0.02 and phosphorus 0.026 per cent in bar form 2 inches in diameter was oil hardened at 850 degrees Cent. and two lots *A* and *B* tempered at 650 degrees Cent.; the one lot *A* cooled in the furnace; the other lot *B* cooled by quenching from the tempering temperature. Twelve test pieces in *A* and in *B* give the average results shown in Table II.

While it is stated that a notch brittle, nickel chrome steel shows a crystalline impact fracture and is an undesirable material, the converse, of course,

Table III
Chemical Composition of One Series of Steels Tested

Steel No.	Carbon per cent	Manganese per cent	Phosphorus per cent	Sulphur per cent	Nickel per cent	Chromium per cent
1..........	0.38	0.45	0.011	0.036	....	....
2..........	0.15	0.42	0.013	0.035	....	....
3..........	0.30	0.58	0.012	0.019	1.52	0.46

does not necessarily hold, that is, a crystalline fracture may not by itself demonstrate an undesirable material. The nature of these fractures must be judged in the light of their relation to the composition and the mechanical properties of the material. A crystalline fracture in medium carbon material as rolled may not be bad because this is normal for that material, but such a fracture for nickel chrome is abnormal and, consequently, is to be avoided.

There is still another feature of the impact test which must be considered, that is, the value of this test as indicative of the structure from examination of the fractured specimens. The tensile test is valuable in view of its being the repositore of a great deal of knowledge gained from its extended use. In a similar manner, an actual examination of fractured impacts will also contribute to making these tests valuable when these have been adopted more widely than at present. For example, and one which is by no means an isolated one, a material in the notch brittle condition always shows a crystalline impact fracture, while the corresponding tensile fracture is fibrous. It can be concluded, therefore, that such a material is unsuitable for structural purposes. This section deals with a series of tests which were carried out at East Pittsburgh to demonstrate these truths.

Three pieces of material 5 inches in diameter and 15 inches long of the analysis given in Table III were given the treatments as specified in Table IV, a series of test pieces being machined therefrom after each heat treatment operation. The test results which were obtained are shown in Table V, the numbers in the first column indicating the steel number and series, respectively, as shown in Table IV.

The bend test pieces were ground all over to ⅝-inch in diameter and bent over supports 4 inches apart to a radius of 0.5 inch. With the ex-

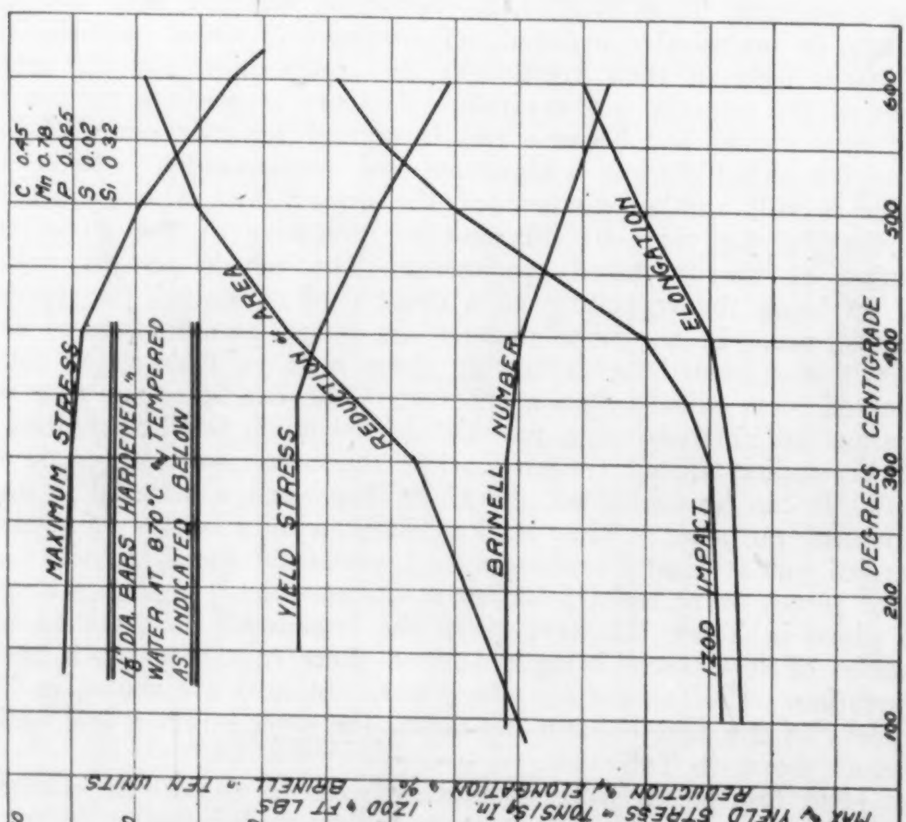


Fig. 11—Physical properties of 1⅛-inch diameter bars hardened in water at 870 degrees Cent. and tempered as shown

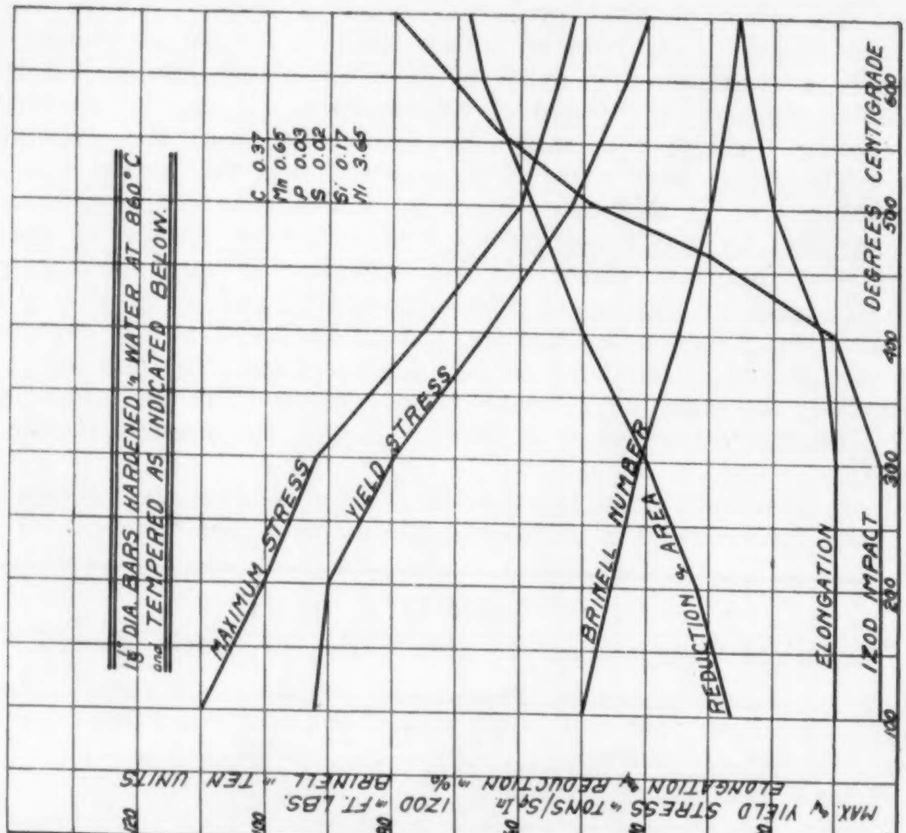


Fig. 12—Physical properties of 1⅛-inch diameter bars hardened in water at 860 degrees Cent. and tempered as shown

Table IV

Heat Treatments Given Steels Tested

Steel No. 1, Series No. 1

The material was drawn from stock as rolled and one quadrant cut out. Three tensiles, 3 impacts and 3 bend test pieces were machined for test.

Steel No. 1, Series No. 2

The material was normalized by putting it in the furnace at 450 degrees Cent., bringing it up to 875 degrees Cent. and holding it at that temperature for 2½ hours and then cooling it in the air. The test pieces were then machined from a second quadrant.

Steel No. 2, Series No. 1

The material was drawn from stock as rolled and one quadrant cut out. The test pieces were machined as before.

Steel No. 2, Series No. 2

The material was normalized as previously described and test pieces were machined as before from a second quadrant.

Steel No. 3, Series No. 1

The material was forged down from billets to 5 inches in diameter and test pieces were machined from one quadrant.

Steel No. 3, Series No. 2

The material was normalized in a similar manner and test pieces were machined from a second quadrant.

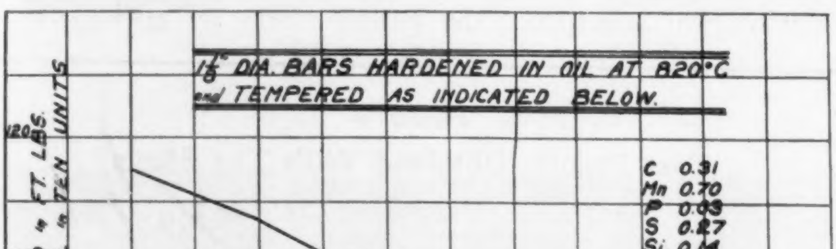


Fig. 13—Physical properties of 1⅛-inch diameter hardened in water at 820 degrees Cent. and tempered as shown

ception of the material No. 1 in the rolled condition, the bend tests went to 180 degrees without a sign of fracture. The impact tests, however, showed a somewhat different selection, indicating that this test is very sensitive. The macrographs of these tests are shown in Figs. 14 to 19 inclusive, these bring out the crystalline and fibrous natures of a given material and illustrate the assertion that examination of such, is a fund of knowledge.

Contrasted with these, macrographs of a medium carbon steel in an oil treated and tempered condition and also a steel casting unannealed are shown in Figs. 22, 21 and 20. The chemical composition of these steels was as follows:

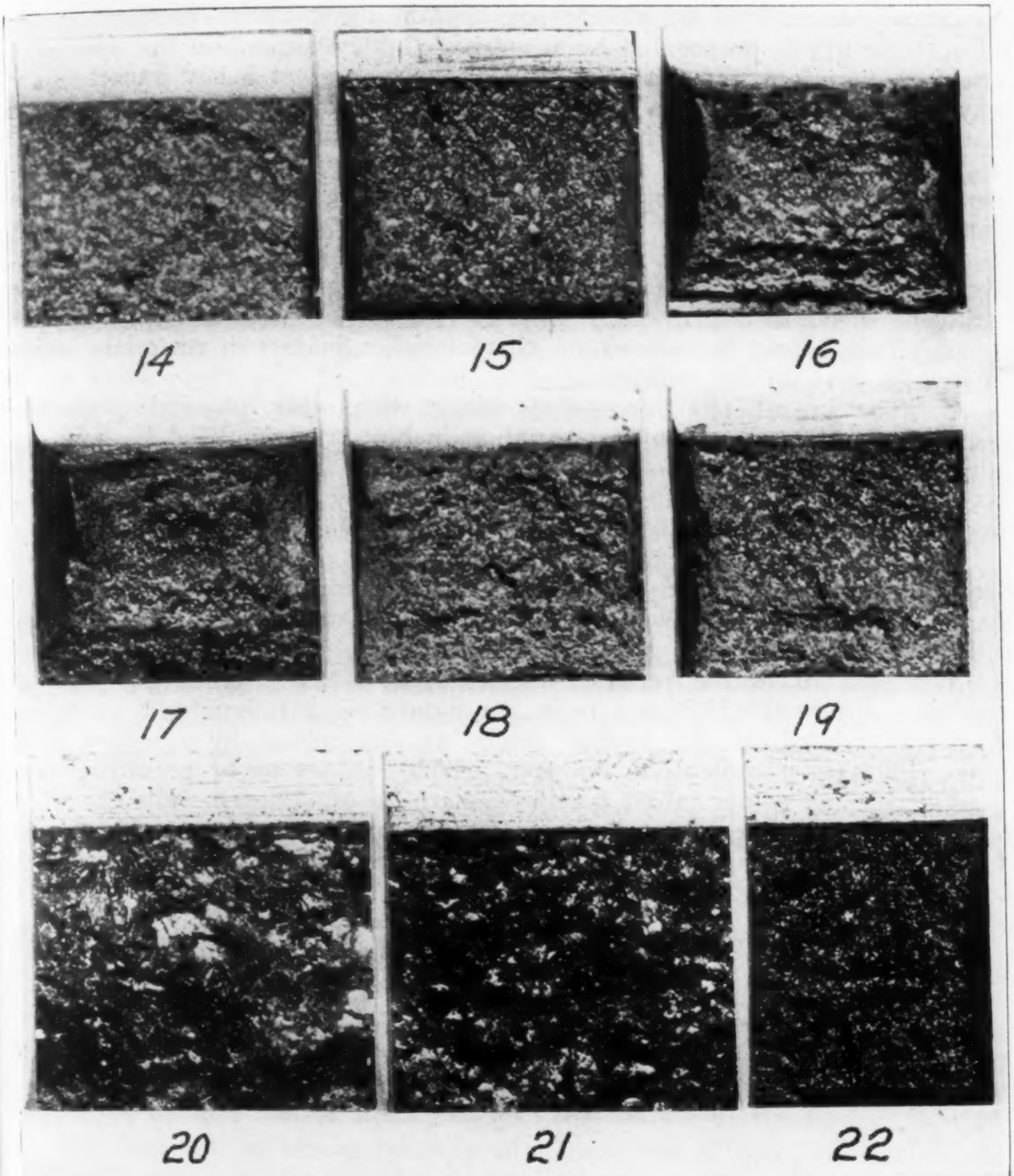
	Carbon per cent	Manganese per cent	Phos. per cent	Sulphur per cent	Silicon per cent	Oil quenched at degrees Fahr.	Tempered at degrees Fahr.
Fig. 20.........	0.13	0.74	0.059	0.119	0.13	Annealed at As cast	....
Fig. 21.........	0.44	0.73	0.06	0.03	0.23	1500	....
Fig. 22.........	0.44	0.73	0.06	0.03	0.23	1500	1150

Caution always must be exercised in drawing conclusions from experimental data. Even with our present knowledge of material testing it is a difficult problem indeed to base a foundation on the results of certain tests. Due to this difficulty there is always the danger of building up a totally erroneous structure. Owing to the importance of this statement from a metallurgical standpoint, the author offers no apology for returning

Table V

Test Results Obtained With The Steels

Steel No. and series No.	Elastic limit —pounds	Yield point per square	Max. stress inch—	Elongation per cent	Reduction of area per cent	Brinell No.	Izod foot pounds	Izod macrograph Fig. No.	Bend test	Remarks
	23,375	28,000	72,400	28.7	38.8	134	7	14	Broke	
1/1	22,000	35,500	71,500	28.7	37.5	136	8	..	Broke	
	22,000	35,400	72,825	28.7	35.7	131	7	..	Broke	
	34,500	36,350	76,750	29.15	45.4	143	10	15	Bent to 180 degrees	
1/2	34,250	37,225	77,625	28.1	43.7	143	12	..	Bent to 180 degrees	
	34,750	36,770	77,575	28.7	46	149	12	..	Bent to 180 degrees	
	25,250	28,670	50,500	42	66.3	101	63	16	Bent to 180 degrees	Impact bent over but not broken off
2/1	25,750	27,400	50,600	42.5	67	104	61	..	Bent to 180 degrees	
	25,750	27,525	50,525	42	66.6	90	61	..	Bent to 180 degrees	
	27,500	28,625	47,670	44.3	73.3	90	40	17	Bent to 180 degrees	Impact bent over but not broken off
2/2	21,750	26,500	47,850	42.85	72.5	96	62	..	Bent to 180 degrees	
	22,750	27,500	47,900	44.9	73.1	101	69	..	Bent to 180 degrees	
	49,250	52,200	93,125	32.2	57.6	181	39	18	Bent to 180 degrees	
3/1	45,000	57,000	93,700	25.2	57.6	179	41	..	Bent to 180 degrees	
	43,750	53,250	92,900	24.15	57.3	179	37	..	Bent to 180 degrees	
	49,500	60,850	99,750	24.1	54.7	192	33	19	Bent to 180 degrees	
3/2	50,500	59,375	99,225	23.6	54.7	192	35	..	Bent to 180 degrees	
	48,750	60,300	98,550	23.0	56	192	32	..	Bent to 180 degrees	



Figs. 14-19—Macrographs of Izod impact fractures showing the crystalline and fibrous structures of the material X4. Fig. 20—Macrograph of medium carbon steel in an oil quenched and tempered condition. X4. Fig. 21—Macrograph of medium carbon steel in an annealed condition. X4. Fig. 22—Macrograph of an unannealed steel casting

again to this subject. For instance the Brinell test has often been put forward as a test in itself, while, as is known, it was never intended for such a use. It has a value only as it is related to some fundamental test such as the tensile test. It seems that this cannot be emphasized too strongly. There is some definite relation between the tensile strength and the Brinell hardness for a given material. Furthermore, attempts have been made in the past to correlate impact values and fatigue limits yet this seems erroneous since the conditions of fracture have nothing in common. The fatigue

fracture is determined by a series of slips in the material itself while the impact fracture is propagated by a notch definitely located in the specimen. The fact, therefore, remains that a material which gives a low impact figure may not necessarily show a low fatigue limit, but it is still revelant to state that the former material is in a notch brittle condition.

Therefore, although it is difficult and dangerous to make definite statements in favor of any particular test the following conclusions seem to be warranted:

1. The impact test of the type here described is one of the most sensitive mechanical tests so far introduced to determine the design of heat treatment given to a material.

2. This impact test shows up characteristics in certain materials which the tensile tests do not indicate.

3. The impact test corresponds along with other physical properties such as reduction of area to the variation in heat treatment and is therefore valuable for confirmatory purposes.

4. The impact test offers valuable evidence, by observation of the fracture, relative to the thermal treatment which the material has received.

Any test which brings out something new or confirms some value already known is valuable. Provided that this impact figure is not purchased at too high a price with respect to the ultimate strength or elastic limit these tests have a very great value indeed.

With regard to the repeated impact such as the Stanton the case is somewhat different. This test is in the nature of a fatigue test and may be closely related to the fatigue limits as determined by standard machines. This is a contention, however, which has yet to be proved.

The various points raised herein seem to be of sufficient importance to those interested in the heat treatment of steels to present them at this time. If enough interest is aroused to provide a satisfacory discussion of his subject the author will feel that his efforts have been well directed. Acknowledgment is extended to the Westinghouse Electric & Mfg. Co., for permission to publish these results and to W. J. Merten and C. H. Marshall for assistance in carrying out the tests described.

IMPORTANCE OF THE PROPER HEATING AND COOLING OF STEEL

By John A. Succop

ONE of the most important sciences in the mechanical field today, and one which necessitates the most careful and skilled application of its principles, if correct results are to be obtained, is the heat treatment of steel. There are certain fundamental facts and considerations which are worthy of attention. Of these facts, one of the most important is uniform results, which minimizes the possibility of low standard work. Uniform results are obtained through proper heating and cooling, and proper loading of the furnace charge. Less trouble is experienced with small masses, for they do not present the same difficulties that are encountered with large furnace loads. It is well known that the molecular changes which occur in steel are not fixed and unchangeable, but depend on both the temperature at which they take place and on the duration of time of changing, upon the rate of cooling and the initial temperature to which the steel has been heated.

It is generally assumed that the proper heat treatment of steel requires nothing more than a uniformly heated product; that a uniform product requires nothing more than a uniformly heated furnace; and that a uniform pyrometer record assures a uniformly heated furnace; consequently, a uniformly heated product within that furnace. When the pyrometer rod is used in a heat treating furnace, it should be so placed that by looking in the furnace door, a direct comparison can be made by the eye as to the temperature of the charge with the temperature at the end of the rod. The pyrometer rod should never be hidden from the eyes of the operator unless the couple be buried in the center of the material and protected from the flames.

From the study of the metallurgical results of the finished products, heat treated in an indicated, uniformly heated furnace, we find that a variation frequently is found. There is a greater problem to heat treating than the maintenance of a uniform temperature in the heating furnace. These variations are not confined only to furnaces of different types; for the variation is found in the same furnace, the pyrometer readings being the same in each case. Such variations are brought about by the position of the load in the furnace and by a difference in the heating of the load.

The best test of the uniformity of a heat treated piece of steel is the manner in which the load cools; for it is the uniformity of the steel as it passes through the critical range and takes its final and permanent set, that gives to steel the results of the heat treatment. To heat uniformly, it is necessary that each piece be subjected to the heat in the same manner, at the same temperature, and for the same length of time in proportion to the size of the section.

If a large amount of material is placed on one end of the furnace charge, it is likely that the outside pieces will be heated to and cooled from a higher temperature than the pieces at the center of the mass. Likewise with cooling, if a large mass is plunged into a quenching tank, there is a tend-

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A paper to be presented at the Pittsburgh Sectional Meeting, May 25-27. The author, John A. Succop, is connected with the Heppenstall Forge & Knife Co., Pittsburgh.

ency for the temperature of the bath to become irregularly heated, and also for the outside of the mass to cool at a different temperature and in a different temperature and in a different period of time than the center.

With large masses, it is unreasonable to suppose that each portion of the section receives the same amount of heat that the other portions received, and that it is subjected to the same heat treatment. Unless all pieces are heated and cooled exactly alike, the pyrometer indications of uniform temperature serve merely as evidence, but cannot be accepted as proof of a uniformly heated furnace, or a uniformly heat treated furnace charge, or a uniformly heat treated product, as a final result. There should be better appreciation and understanding of the difference between a pyrometer record, which indicates a uniform temperature and of the conditions which bring about the uniformity desired in the furnace.

The following is a quotation from Dr. Howe in his book, *Iron, Steel and Other Alloys,* page 241: "You cannot make a bad beefsteak good by the cooking; you can cook it better or worse, and it will be a worse or less bad beefsteak, but always bad. On the other hand, you can easily spoil a good beefsteak by bad cooking. Now, just as cooking is to food, so is heat treatment to steel. Indeed, a pedantic cook might reasonably call cooking, heat treatment." This simile of Dr. Howe's is right to the point; for the application of heat to industrial material is but a cooking operation, like the cooking of food or the baking of bread; each must be thoroughly done—that is, it must be heated uniformly to the center. To cook or heat to the center with the temperature being equal from the surface to the center requires a slow fire and time in proportion to the amount of material to be heated. Overloading, as well as improper loading, will prevent the proper circulation of heat, and it is likely that a part of the charge will rise to the desired temperature in a nonuniform condition, and will cool with even less uniformity than it heated. The indicator on the outside of the oven does not tell the story of the food being well done. This is accomplished by observation of the material.

Even with all our modern present day practice and equipment we must take into consideration the importance of the human element. The heat treater, although the weakest link in the chain of perfection of the product, is the one that puts the metallurgical finish on the material at a great expense to others, and it is his skill and judgment that either perfects or spoils the material. Have we not all heard of the manufacturer who thinks he is protected from all the evils of heat treatment because he has the best pyrometer system that money could buy, with automatic recorders in the office, so that at all times, he knows the condition of the furnace and what each heater is doing? Besides this, he has a man whose sole duty it is to watch these instruments and the temperature recorded on the pyrometer, and to indicate to the operator by a red, green, or blue light just when his temperature is low, high or just right. He is sincere in his belief and he thinks he knows what good heat treating is, but his standard is low, due to the reasoning that a uniformly heated product requires only a uniformly heated furnace, which reasoning leads to the development of the pyrometer to indicate the uniformity of the product.

This is all right as far as it goes, but it does not go far enough, for it may be an indication of the temperature of that particular part of the furnace, but it surely is not proof that the product in the furnace is at that particular temperature, as indicated. The proof for this statement is the

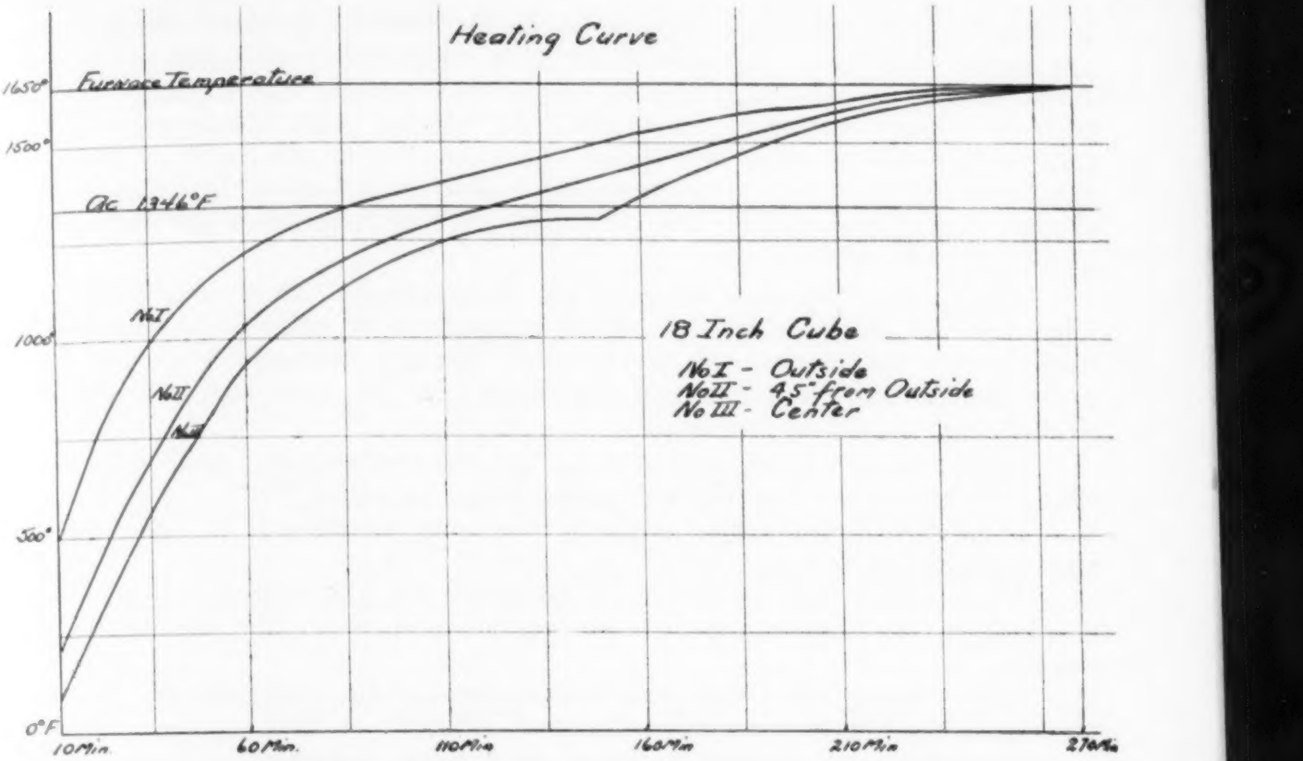

Fig. 1—Curves representing the heating of a steel block 18 inches square showing the rapidity with which the heat penetrates to the center of the mass

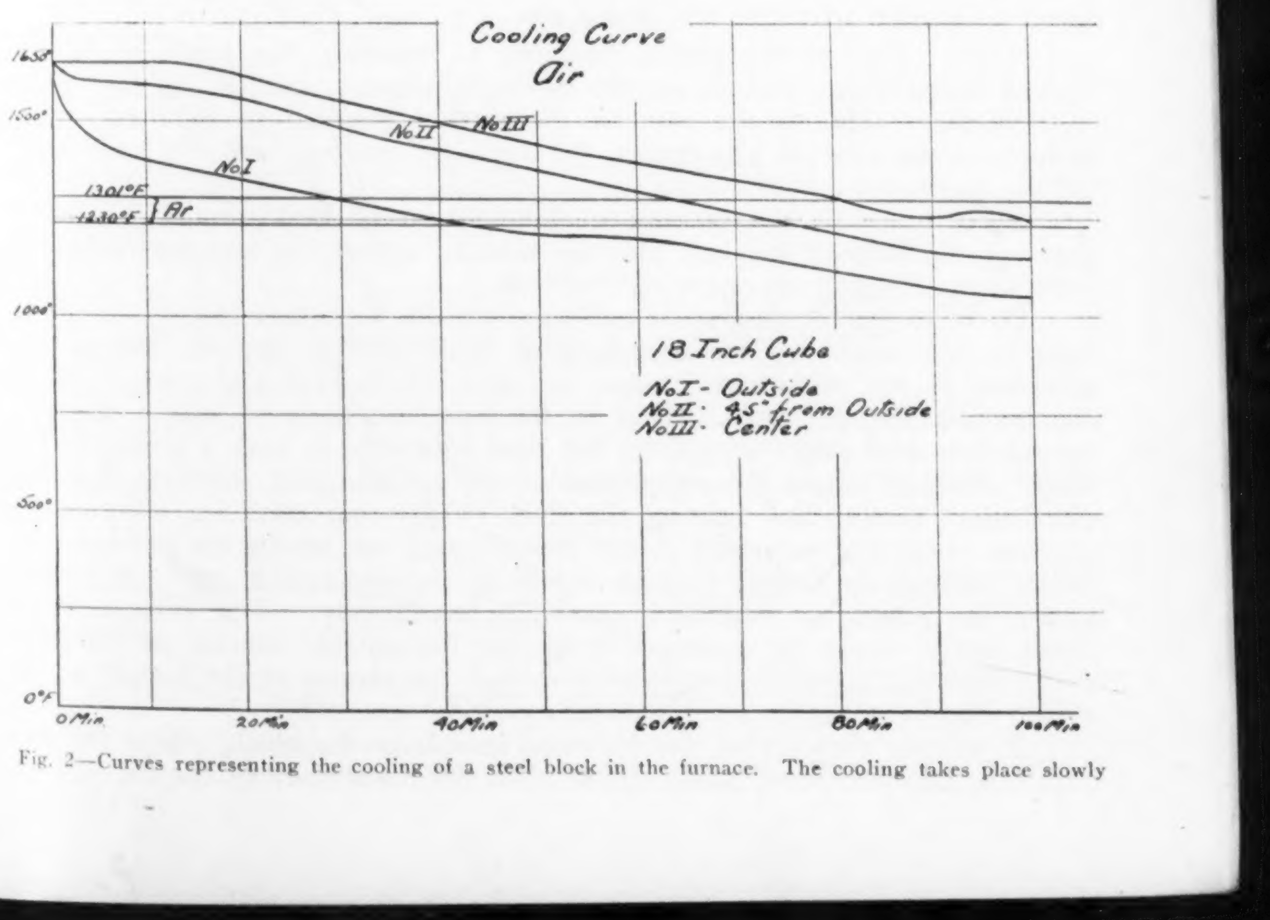

Fig. 2—Curves representing the cooling of a steel block in the furnace. The cooling takes place slowly

trouble we encounter with variations in the finished product, although the pyrometer chart gives no indications of a temperature variation. The uniform heating of a furnace and of the product within that furnace are two entirely distinct operations, and while the former must accompany the latter, yet the former does not prove the existence of the latter. The final conclusion of this analagous reasoning is that it is neither logical nor conclusive, and the actual results all hinge on the experience and knowledge of the man at the furnace.

There are a number of elements that directly affect heat treatment. They are not indicated by the use of pyrometers or other heat determining devices, whether mechanical or electrical, but are determined by the judgment and skill of the operator at the furnace, as the cook judges the quality of the food baked in the oven.

When the pyrometer indicates the desired temperature, what determines when the charge in the furnace is completely saturated?

What determines proper loading conditions as regards to mass heating and gas circulation?

What determines when the temperature of the bottom of the mass is equal to the temperature of the center, and when the top equals the sides?

What regulates the flow and combustions of the fuel into the furnace, causing an oxidizing, reducing, or neutral action?

What regulates the uniformity of each piece, compared with each other piece in the charge, that they might all be treated the same?

The four factors which govern the heating and cooling of all material, whether it be food or an ingot of steel, are temperature, time, surface and mass.

Temperature. This is the degree of heat required to produce the desired molecular structure and grain size.

Time. This is the period required to saturate the piece to the required temperature, and to permit the metallurgical reactions to take place.

Surface. This is the area of the section exposed to the heat, which influences the rate of absorption, the time of soaking, and the uniformity of the piece.

Mass. This is the amount of material to be heat treated, which influences the time of heating, and the time of saturation and uniformity, as well as the manner of supplying the heat.

Of these four, temperature and time are the important factors. Temperature is determined by the metallurgical effect that is desired, but time is governed by the surface and mass, and also by the type and composition of the material being treated. That is, the time necessary to soak a piece of low carbon steel might vary from the time necessary to soak a piece of alloy steel. Soaking means the completion of the metallurgical reactions that take place upon cooling and heating the steel. Often our time for allowing the sections to become saturated is not enough, and our results are not uniform. When loading, the largest surface should be exposed to the source of heat to insure the minimum time and maximum uniformity. The reverse would mean that it would be necessary to expose the outside surface of the mass to the heat for a greater length of time than the section at the bottom of the mass. Ideal cooling is just the same condition reversed.

A striking example of this is found in a large die block, where the corners heat and cool much more rapidly than the main body of the die. Every

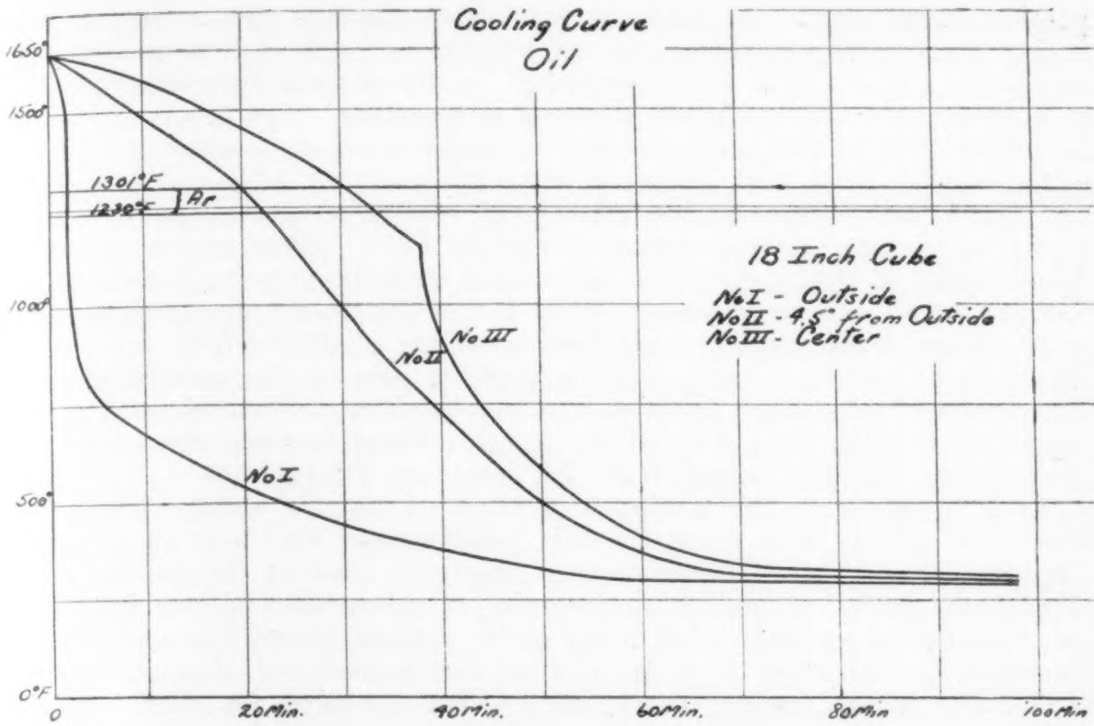

Fig. 3—Curves representing the cooling of a steel block in quenching oil, the rapidity of cooling being due to large volume of oil and its rapid circulation

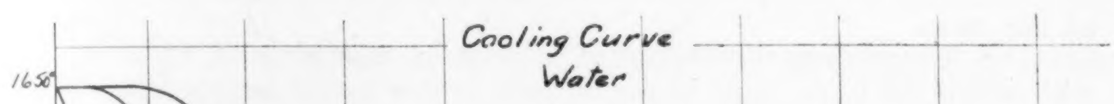

Fig. 4—Curve of a steel block heated to 1650 degrees Fahr. and cooled on knife edges by a high pressure water spray. Cooling is more rapid than in the water quench

possible effort should be made to prevent overheating the corners or exposing them to the extreme final temperature any longer than is absolutely necessary. This might be accomplished by thoroughly saturating the dies at a temperature slightly below the final temperature. The corners of a die, because of the greater surface, heat first and cool off first, and cause an unequal expansion and contraction in the steel.

The effect of mass on the heating and cooling of steel might be clearly shown by a study of the curves developed by Law. These curves were produced under as ideal a condition as possible, and they represent the changes that are found in a large mass of steel during the heating and cooling. The curves were developed by the following means: Eighteen-inch cubes were forged from a 25-inch ingot, only the soundest part of the ingot being used. The thermocouples were inserted into the cubes to be treated—one in the center; 4½ inches from the center, that is midway between the center and the outside; and one ¼-inch from the center of the surface.

Fig. 1 represents the heating of a block of steel 18 inches square, and shows the rapidity with which the heat penetrates to the center of the mass. The center and outside temperatures approach each other before going through the critical range, but at this point, the absorption of heat due to the Ac change causes a greater lag at the center than anywhere else, and the two temperatures fall away from each other for a period of time. However, after being in the furnace for about 4½ hours longer, the cube attains a uniform temperature throughout its mass, and practically coincides with the temperature of the furnace.

Fig. 2 represents the cooling of a block in the furnace. These curves require no explanation. The cooling takes place slowly, and as in the case of the heating curves, the evolution of the heat is most marked in the center of the mass.

Fig. 3 represents the cooling of a block in quenching oil. The rapidity with which the block cools in the oil bath is due to the large volume of oil and the rapid circulation.

The block shown in Fig. 4 was heated as before to 1650 degrees Fahr. and cooled on knife edges by a high pressure water spray. The block, as would be expected, cools off more rapidly than the oil quench. The curve also shows an evolution of heat in the center. Attention is called to the abrupt halt in the cooling at about 250 degrees Fahr. It is hardly likely that this halt is caused by the water getting into the thermocouple hole, because the temperature remains constant for so long a time, and at 50 degrees above the temperature of boiling water. Experiments repeated on various sizes of blocks show that the phenomenon occurs with remarkable regularity and is not affected by mass.

The existence of a low critical point has been verified by a large number of scientists, and if proved correct, will throw a new light on the phenomenon of hardening in steel.

Law sums up the essential features of the curves as follows: "The extreme slowness of air cooling, as compared with either water or oil cooling, is too obvious for comment. A comparison of the curves obtained by oil and water cooling, however, is of greater interest. The important difference between the two methods of cooling is to be found in the almost sudden slowing up of the cooling in oil shown in the lower ranges of temperature, as compared with the cooling in water. For example, the time required for the center of the cube to cool from 1650 to 1000 degrees Fahr., a tempera-

ture well below the critical range, is almost the same whether oil or water is used as the quenching medium. In cooling from 1000 to 600 degrees Fahr., however, the cube cooling in oil requires twice the time, and in cooling from 600 to 300 degrees Fahr., it requires nearly four times as long. The differences are even greater on the outside of the cube. The oil cooled surface takes six times as long as the water cooled surface to cool from 600 to 300 degrees Fahr. It may be observed with interest that both in oil and water cooling, there is a period during which the metal in the center of the cube is cooling down more rapidly than the metal midway between the center and the surface."

These factors hold good with a furnace loaded with both large and small pieces where, in order to cut the cost, the load is heated according to the perfection of the small pieces. Although the initial costs are increased, the best results are obtained by heating according to the largest section, which undoubtedly will pay in the end for the additional time necessary, but an ideal condition would be to heat treat as nearly as possible, loads made up of parts of uniform size.

The practice of heat treating without regard to the mass and surface and with an eye only on the record of the pyrometer, will always produce a nonuniformly heated product. The mass should be heat treated and not the pyrometer. The pyrometer does not indicate anything concerning the temperature of the mass, but only the temperature of the portion of the gases in the furnace or the material with which it comes in contact.

Proper consideration must be given to the human element involved. Those in charge should be educated and should in turn educate those within their charge, for upon them lies the future of subsequent operations.

From the foregoing discussion, the following conclusions might be drawn:

1. That a uniformly heated product requires more than a uniformly heated furnace.

2. That material cannot be heat treated satisfactorily when the record of the pyrometer is the only guide.

3. That the human element plays an important part in the proper heating and cooling of steel.

4. That great care must be exercised in the handling of steel to insure proper thermal expansion and contraction. This is secured only through proper loading, charging at a low temperature, and by slow firing.

THE ABRASIVE QUALITIES OF PLAIN CARBON AND ALLOY STEELS

By A. M. Cox

MODERN equipment is designed for high speed and heavy duty. The manufacturers have met this condition by using heat treated plain carbon and alloy steels in moving parts, such as gears, cams, etc. Application of various types and grades of steel has brought forward the fact that any one steel cannot be used indiscriminately but must be studied in relation to the service for which it is intended. This paper gives the results of a series of tests as an introductory study of the effect of heat treatment on the abrasive qualities of plain carbon and alloy steels; after having been sujected to various heat treatments.

The machine used for these tests is shown in Fig. 1. The type of rollers used are shown also. The arrangement of the rolls and the dimen-

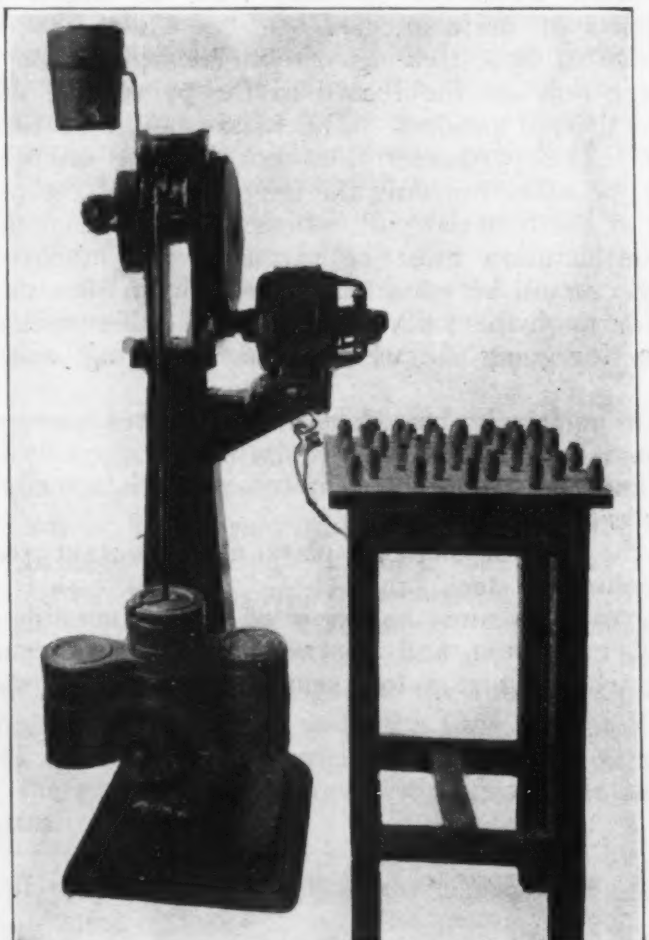

Fig. 1—Machine used for making abrasive tests on steel rollers

sions of the test roller are shown in Fig. 2. The pressure on the test roller is a dead load of 240 pounds. The machine is direct motor-driven

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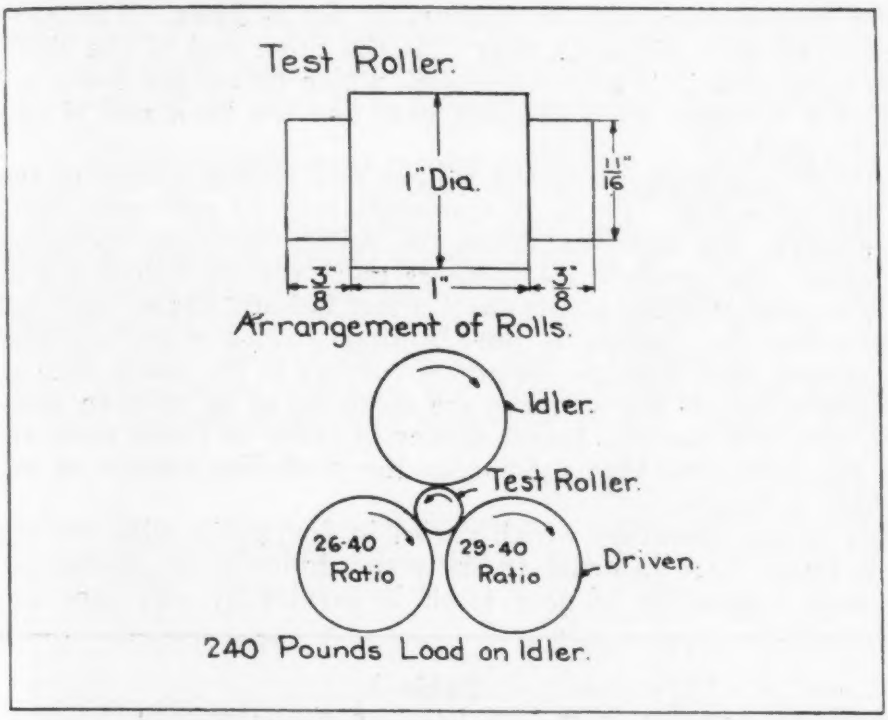

Fig. 2—Arrangement of rolls and dimensions of test roller. For each revolution of the counter, the front driven roll turns 100 revolutions while the test roller turns 300 revolutions or 750 revolutions per minute

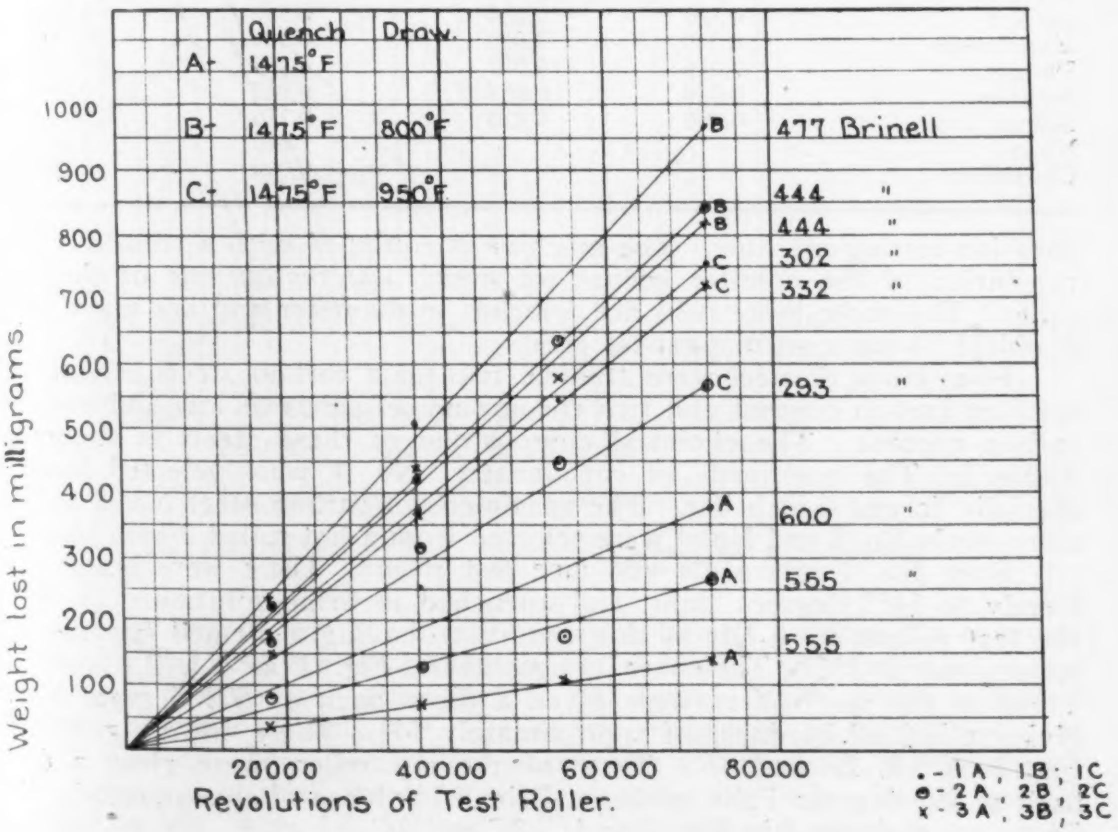

Fig. 3—Curve showing wear of plain carbon steel No. 1, brine quenched

having a motor speed of 1140 revolutions per minutes. The 20-tooth motor pinion drives a 106-tooth gear. At the other end of the shaft holding the 106-tooth gear is a 40-tooth pinion, which drives the lower rolls. The front roll is operated by a 29-tooth gear and the back roll is operated by a 26-tooth gear.

This arrangement gives the rolling and sliding action to which gear teeth are subjected. There is approximately 10 per cent sliding at all times whereas the ratio of sliding to rolling obtained in involute gear teeth varies. An involute tooth wears more rapidly below and above the pitch line since at these points the contact is both sliding and rolling. At the pitch line the contact is pure rolling. Since these extreme contact points should pass through the arc of contact in the same time as a point on the pitch line, if the surfaces are worn so as to shorten their arcs of contact, they will have to travel slower in order to cover their arc of contact in the same time that a point on the pitch line covers its arc of contact which is longer.

This causes vibration which varies in frequency with the speed. The above is stated here in order to show the difficulty in approximating the actual wear conditions of gear teeth in service by any type of wear or

Table I
Chemical Composition of Steels Tested

Per Cent	Carbon Steel No. 1	Carbon Steel No. 2	Chrome Nickel Steel No. 3	Chrome Nickel Steel No. 4
Carbon	0.520	0.226	0.550	0.240
Manganese	0.340	1.020	0.300	0.290
Phosphorus	0.016	0.077	0.030	0.032
Sulphur	0.039	0.063	0.042	0.039
Silicon	0.090	0.030	0.170	0.130
Nickel			1.840	1.490
Chromium			0.990	1.150

abrasion testing machine. The machine is equipped with a counter. One revolution of the counter occurs for every 100 revolutions of the first roller. The three large rolls are 3 inches in diameter and are made from Hadfield 14 per cent manganese steel.

Four kinds of steel were studied, two plain carbon steels of low and medium carbon content and two chrome nickel steels of low and medium carbon content. The chemical composition of these steels is shown in Table I. The specimens of carbon steel No. 1 were selected from a specially forged 6-inch bar. The specimens of carbon steel No. 2 and of alloy steels No. 3 and No. 4 were selected from a hot-rolled 2-inch bar.

Steel No. 1 was made into nine test rollers. These were heated uniformly to 1475 degrees Fahr. and quenched in brine solution. Three of the test rollers were left in this condition, having a Brinell hardness of approximately 555. These are designated in Fig. 3 as 1*A*, 2*A* and 3*A*. Three of the test rollers were given a draw back at 800 degrees Fahr. giving a Brinell hardness of approximately 444. These are designated in Fig. 3 as 1*B*, 2*B* and 3*B*. Three of the test rollers were given a draw back at 950 degrees Fahr. giving a Brinell hardness of approximately 302. These are designated in Fig. 3 as 1*C*, 2*C* and 3*C*.

Steel No. 2 was made into six test rollers. These were carbonized

at 1750 degrees Fahr. to give a 1/10-inch case. Three of the test rollers were heated uniformly to 1380 degrees Fahr. and quenched in brine solution, then given a draw back at 350 degrees Fahr. in oil. The scleroscope hardness averaged 89 to 91. This treatment is known as single quench case hardening.

Three of the test rollers were heated uniformly to 1475 degrees Fahr. and quenched in oil. They are reheated to 1380 dgrees Fahr. and quenched in brine solution and given a draw back at 350 degrees Fahr. in oil. The scleroscope hardness averaged 88 to 89. This treatment is known as double quench case hardening S. A. E. treatment G. Steel No. 2 is designated in Fig. 5 as 1*S*, 2*S* and 3*S* and 1*D*, 2*D* and 3*D*. *S* represents the single quench and *D* the double quench treatments.

Steel No. 3 was made into nine test rollers. These were heated uniformly to 1425 degrees Fahr. and quenched in oil. Three of the test

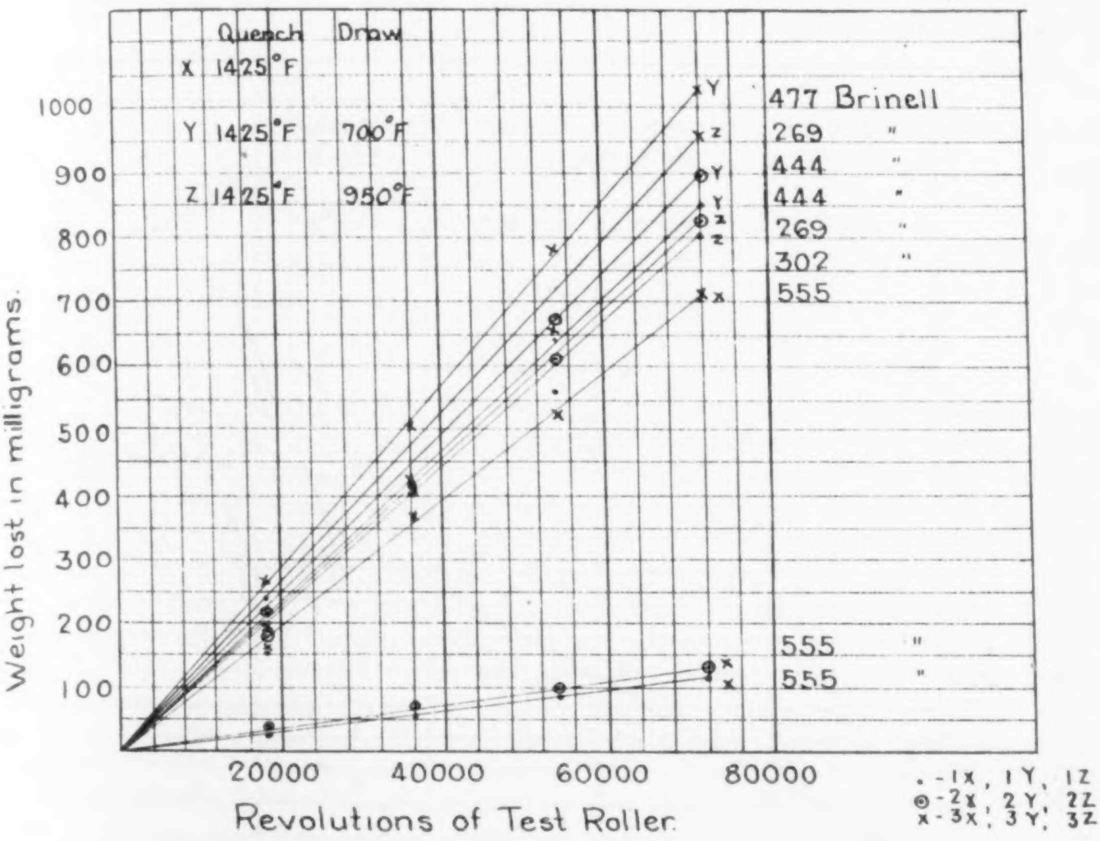

Fig. 4—Curve showing wear of chrome nickel steel No. 3, oil quenched

rollers were left in this condition, having a Brinell hardness of approximately 555. These are designated in Fig. 4 as 1*X*, 2*X* and 3*X*. Three test rollers were given a draw back at 700 degrees Fahr. giving a Brinell hardness of approximately 444. These are designated in curve Fig. 4 as 1*Y*, 2*Y* and 3*Y*. Three test rollers were given a draw back at 950 degrees Fahr. giving a Brinell hardness of approximately 302. These are designated in Fig. 4 as 1*Z*, 2*Z* and 3*Z*. The treatment given is similar to S. A. E. treatment F.

Table II
Average Wear in Milligrams Per 18,000 Revolutions

Material	Weight	Hardness Brinell	Weight	Hardness Brinell	Weight	Hardness Brinell	Markings
Carbon	94.9	600	* 55.0	555	36.5	555	A -1, 2 and 3
Steel	243.0	477	*212.0	444	207.0	444	B -1, 2 and 3
No. 1	189.0	302	*142.0	293	132.4	332	C -1, 2 and 3
Chrome Nickel	29.4	555	* 32.4	555	179.0	555	X -1, 2 and 3
Steel	213.8	444	*225.1	444	258.9	477	Y -1, 2 and 3
No. 3	203.0	302	*210.5	269	239.7	269	Z -1, 2 and 3
		Scleroscope		Scleroscope		Scleroscope	
Carbon	S. 25.9	90	* 26.3	91	23.1	91	S -1, 2 and 3
Steel No. 2	D. 26.1	89	29.3	88	* 20.6	89	D -1, 2 and 3
Chrome nickel	S. 19.0	89	26.4	92	* 28.4	89	S -1, 2 and 3
Steel No. 4	* D. 30.1	89	18.1	88	35.3	89	D -1, 2 and 3

Test roller weighed 136 grams approximately. Total revolutions of test roller—72,000. Total distance covered—3.6 miles.

S—Single Treated, Case Hardened. D—Double Treated, Case Hardened. *Taken for Micro-Photo.

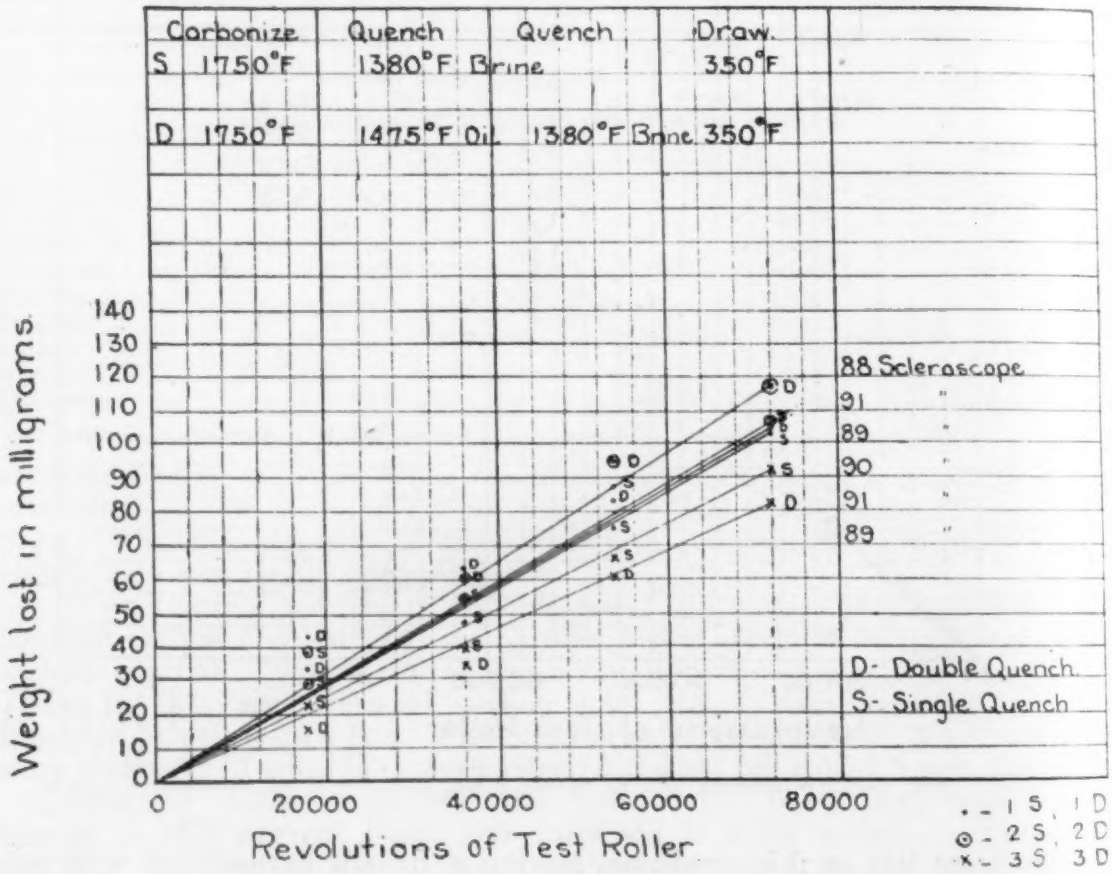

Fig. 5—Curve showing wear of plain carbon steel No. 2, case hardened

Steel No. 4 was made into six test rollers. These were carbonized at 1750 degrees Fahr. to give a 1/10-inch case. Three of the test rollers were heated uniformly to 1400 degrees Fahr. and quenched in brine solution and then given an oil draw at 350 degrees Fahr. The scleroscope hardness averaged 89 to 92. Three of the test rollers were heated uni-

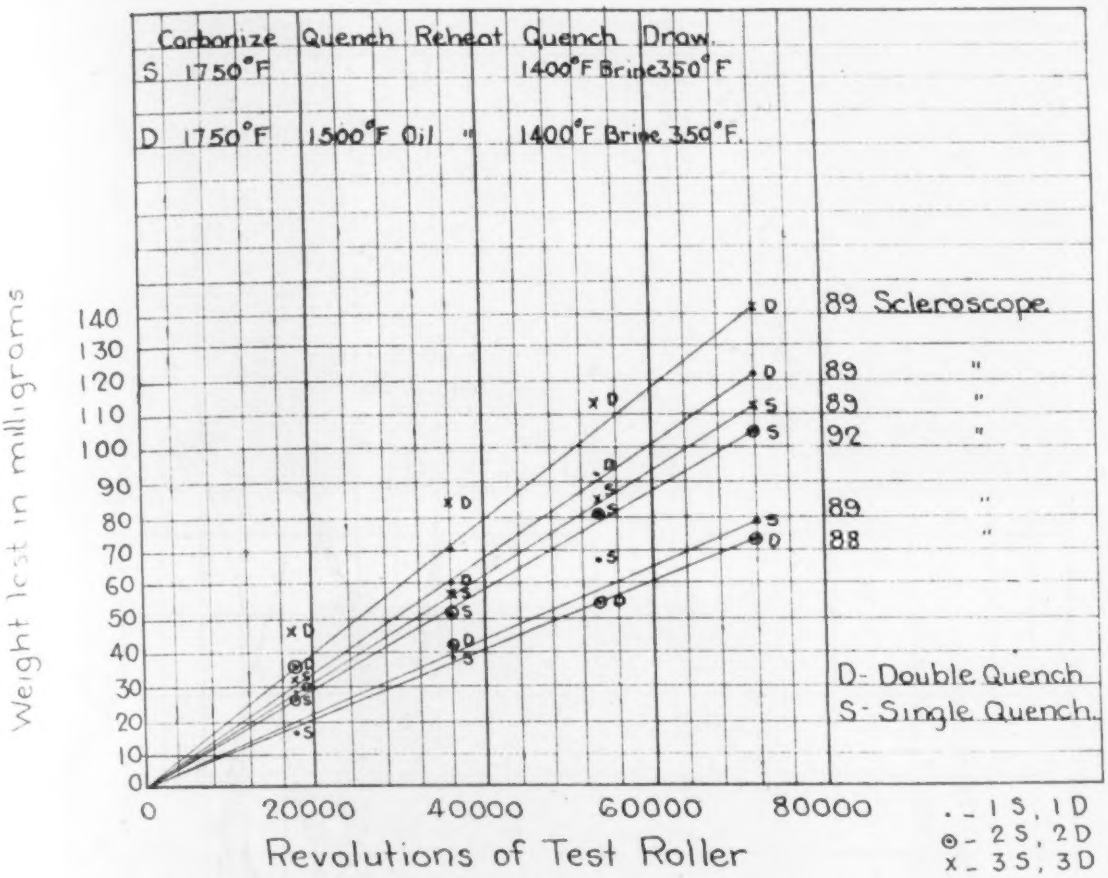

Fig. 6—Curve showing wear of chrome nickel steel No. 4, case hardened

formly to 1500 degrees Fahr. and quenched in oil. They were reheated to 1400 degrees Fahr. and quenched in brine solution, then given an oil draw at 350 degrees Fahr. which is S. A. E. Treatment G. The test rollers were turned 0.010-inch oversize on the outside diameter to allow for grinding after heat treatment. This eliminated any slight decarbonization that may have occurred at the surface of the test rollers.

One inch bars were made from steel No. 1 and steel No. 3. These were heat treated as shown in Figs. 7 and 10 and are designated *A, B, C,* and *X, Y, Z* respectively. Tension tests were then made from these bars, to compare the physical properties with the abrasive properties.

The small test rollers were weighed on a laboratory balance accurate to 0.1 milligram. Each run between weighings consisted of 60 revolutions of the counter or 18,000 revolutions of the test roller. The time of each run was 24.5 minutes. The results were plotted using the revolutions of the test roller as abscissas and weight lost in milligrams as ordinate.

A study of Fig. 3 shows that when the Brinell hardness of steel No. 1 falls below the maximum that can be obtained for that particular steel, the wear loss does not follow the Brinell hardness. Also in Fig. 7 the average wear obtained from the three ranges of hardness is plotted with the physical properties over the same hardness range. Here we find the wear increasing at 470 Brinell and then decreasing at 302 Brinell. The wear loss of each test roller was in a straight line ratio. The structures of the three specimens are shown in Fig. 8.

The curve in Fig. 4 shows the plotted results of the wear loss of steel

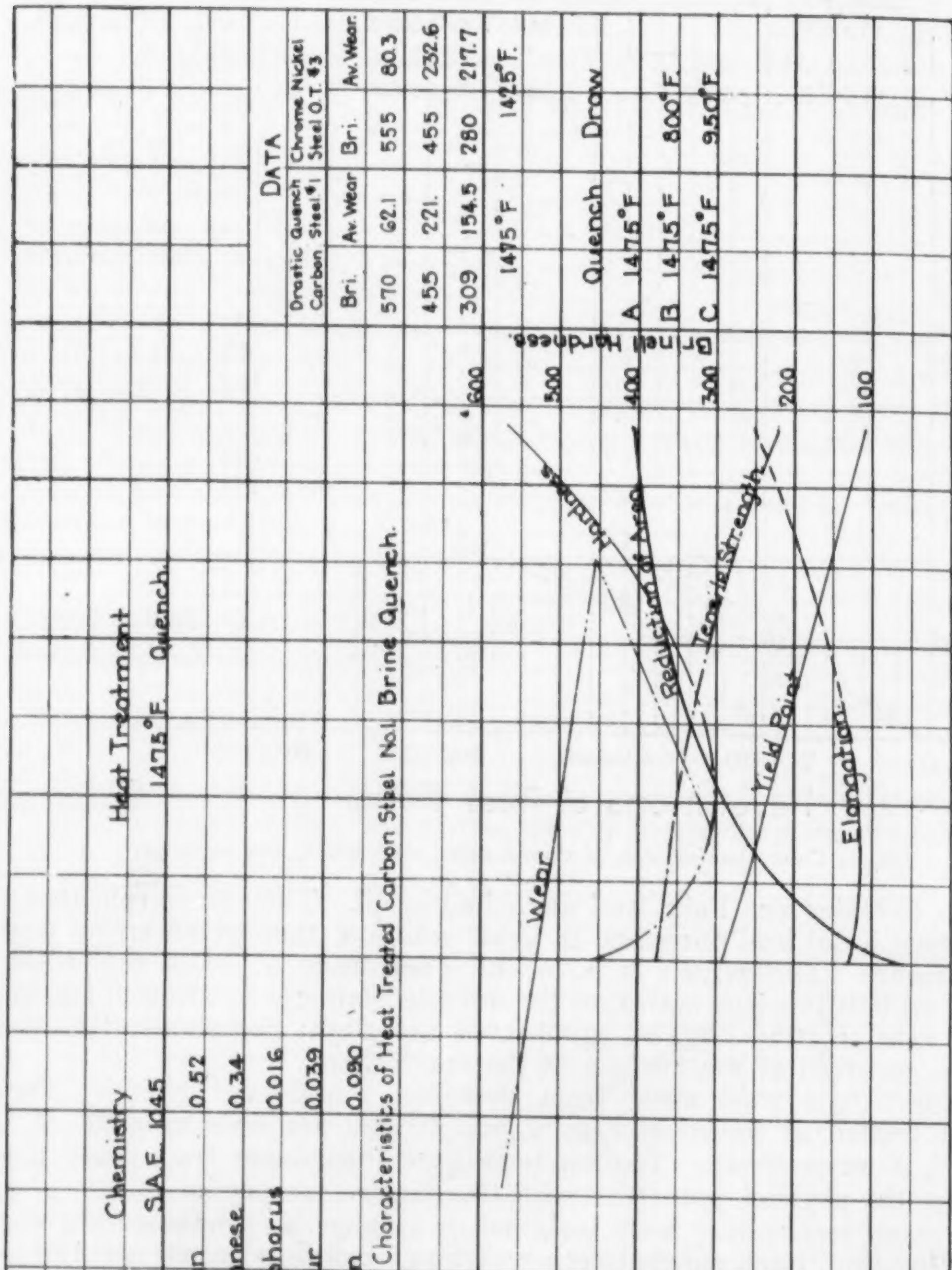

Fig. 7—Curves showing physical properties and wear of plain carbon steel No. 1, brine quenched

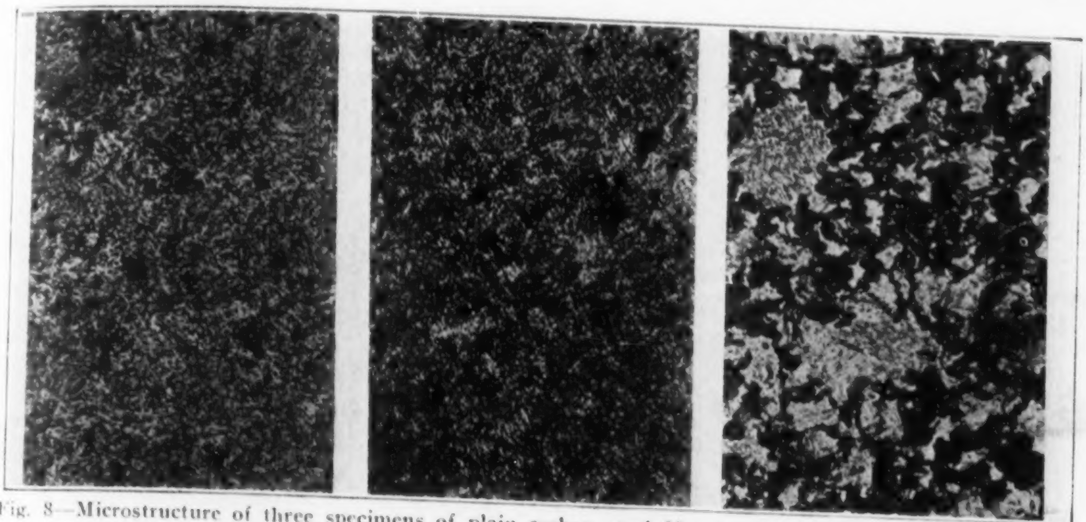

Fig. 8—Microstructure of three specimens of plain carbon steel No. 1. At the left is shown specimen 2A, in the center 2B and at the right 2C

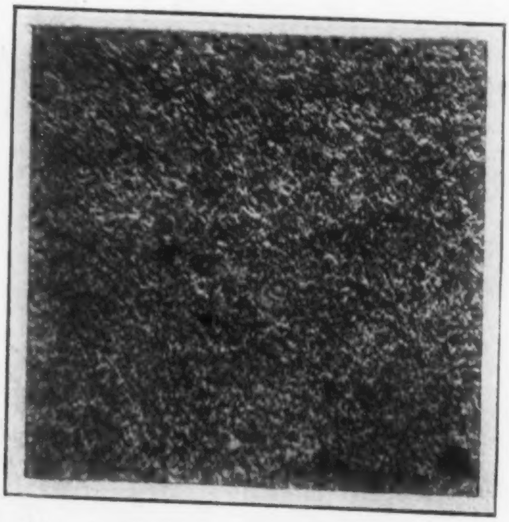

Fig. 9—Microstructure of chrome nickel steel No. 3, specimen 2X. X 100.

No. 3 per revolution of the test rollers. Test roller 3X gave greater weight loss than 1X and 2X. This occurrence has no apparent explanation unless characteristic of the chrome nickel steel. Examination under the microscope disclosed no surface decarbonization or a changed structure. The area covered by steels No. 1 and No. 3 is approximately the same. The structure of test roller 2X is shown in Fig. 9. The structures of 2Y and 2Z showed practically the same structure as 2X.

The curve in Fig. 10 shows the plotted results of the physical properties of steel No. 3 and the average wear loss over the three hardness ranges. Note the wear loss curve is similar to the wear loss curve of the plain carbon steel shown in Fig. 7; increasing at 460 Brinell and decreasing at 302 Brinell.

The curve in Fig. 5 shows the plotted results of the wear loss of steel No. 2 per revolution of the test rollers. The single quenched test rollers gave a slightly better wear than the double quenched test rollers. Photomicrograph Fig. 11 shows the microstructure of the 2S and the 3D test rollers.

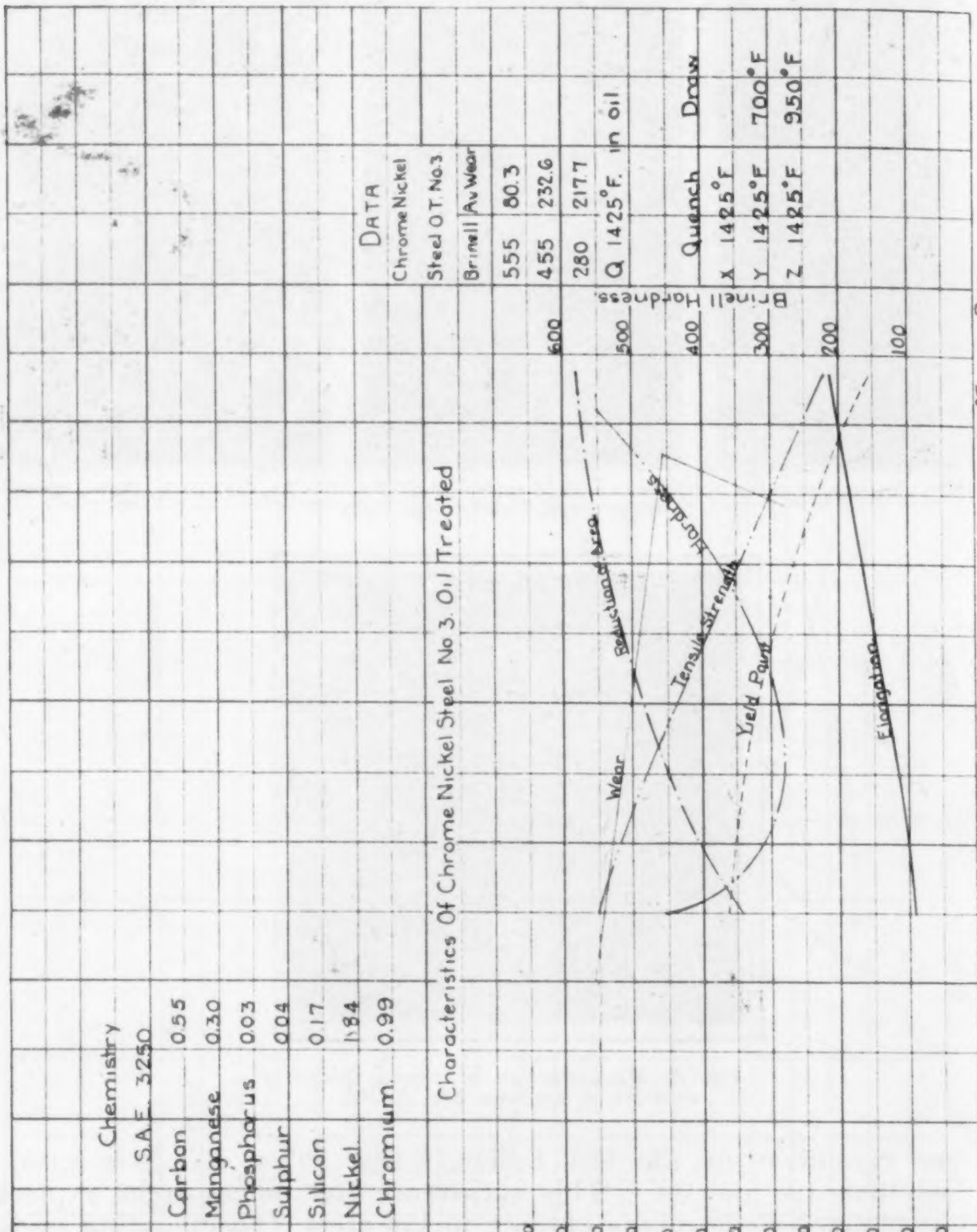

Fig. 10—Curves showing physical properties and wear of chrome nickel steel, No. 3, oil quenched

The curve in Fig. 6 shows the plotted results of the wear loss of steel No. 4 per revolution of the test rollers. Here also the single quenched test rollers gave better wear results than the double quenched test rollers. Photomicrograph Fig. 12 shows the microstructure of the 3S and the 1D test rollers.

In order to get a better perspective of the four steels tested the average wear in milligrams per 18,000 revolutions of the test rollers have been tabulated in Table II. The total linear distance covered by each

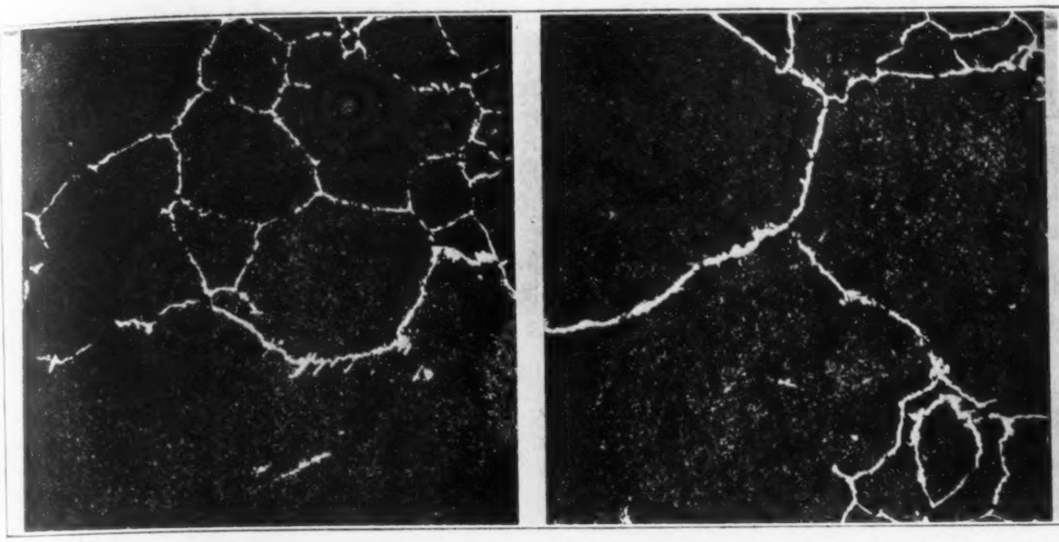

Fig. 11—Microstructure of two specimens of plain carbon steel, case hardened. At the left is specimen *2S* and at the right is *3D*

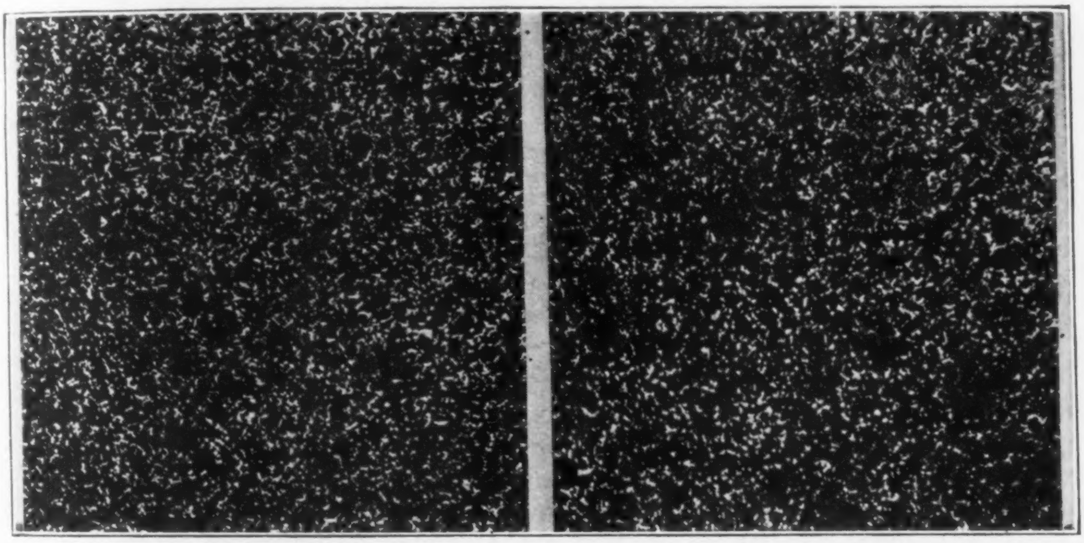

Fig. 12—Microstructure of two specimens of chrome nickel steel No. 4, case hardened. At the left is specimen *3S* and at the right is *1D*

test roller was 3.6 miles. The same markings were used so that any one specimen may be followed on the curves or in the tables. The average wear was based on 18,000 revolutions of the test roller so that appreciable amounts of weight loss could be tabulated.

Based on the tests made under the conditions which have been described, the following conclusions are drawn:

1. These tests are preliminary and are published in hope that a more general discussion will be promoted on the properties of metals to determine the relative wear as affected by steels that rub, one against the other.

2. The test results indicate that the greater the density and hardness, the greater the abrasive resistance.

3. The ordinary tension and Brinell tests are not a reliable index to the abrasive qualities of a material.

4. The carbon steels showed more uniform results than the chrome nickel steels and less average wear loss.

5. Further tests will have to be made to determine the combined effect of ductility and hardness on the abrasive properties of materials.

THE CHANGE IN DIMENSIONS OF HIGH SPEED STEELS IN HEAT TREATMENT

By Marcus A. Grossmann

SOME time ago when data was desired on the shrinkage of high speed steel due to heat treatment, a search of the literature failed to reveal any such data. It was, therefore, decided to carry out a series of measurements on high speed steels of three different compositions in common use. The steels were selected from stocks having approximately the following compositions:

	Steel 18 per cent	Steel 15 per cent	Steel 13 per cent
Carbon	0.65	0.65	0.85
Tungsten	18.0	15.0	13.0
Chrome	3.5	3.5	3.5
Vanadium	1.0	0.50	0.50

The property measured was the change in length after heat treatment. The test pieces were cylinders 1½ inches in diameter and about 2½ inches long. They were measured with ordinary 3-inch micrometer calipers. In making the first set of measurements, reported elsewhere ("Shrinkage and Expansion of a High Speed Steel Due to Heat Treatment," M. A. Grossmann, *Chemical & Metallurgical Engineering*, May, 1922), it was found that two precautions should be taken in making length measurements in this way. One, obviously, was to protect the ends of the test pieces from oxidation; the other was to have the planes of the ends parallel, so that the measurements would be concordant even if not taken at exactly the same point on the test piece. The former was accomplished by bolting protecting pieces on the ends of test piece, as shown in Fig. 1. When this was done, about half of the area of the end, at the center, was perfectly clean without a trace of oxidation, although the hardening was done at temperatures up to 2300 degrees Fahr. in an open furnace. The planes of the ends were made parallel by cutting the test pieces in a lathe. The ends of the test pieces and the faces of the protecting disks were then ground smooth, and the resulting surfaces were in sufficiently close contact to keep air from the ends. If the machine work is done carefully, there is no difficulty in keeping the ends clean.

The length of the cylinders was measured in the annealed condition as prepared, then in the quenched condition after hardening, and then after drawing at various temperatures. Care was taken to make all measurements when the test pieces were at approximately the same temperature, about 70 degrees Fahr. The same test pieces were used for the successively higher drawing temperatures after any one quench, but no individual piece of steel was quenched more than once. Three different series of steels were hardened at successively higher temperatures and then drawn and measured. Each series was carried through independently at different times.

The values obtained are given in Tables I, II and III, and a general chart derived from each of these tables is given in Figs. 2, 3 and 4 re-

A paper to be presented at the Pittsburgh Sectional meeting, May 25-27. The author, Marcus A. Grossmann, is metallurgist, Electric Alloy Steel Co., Charleroi, Pa.

Table I

Steel 18. Length of Cylinders After The Heat Treatments Indicated

Quench temp. degrees Fahr.	Dimensions in inches							
	Original	As quenched	Drawn at 300 degrees Fahr.	Drawn at 500 degrees Fahr.	Drawn at 700 degrees Fahr.	Drawn at 900 degrees Fahr.	Drawn at 1100 degrees Fahr.	Annealed
1900.......	2.5061	2.5060	2.5057	2.5067	2.5066	2.5065	2.5065	2.5056
2100.......	2.5516	2.5519	2.5523	2.5526	2.5525	2.5519	2.5530	2.5511
2300.......	2.5165	2.5180	2.5178	2.5174	2.5169	2.5165	2.5169	2.5159
2000.......	2.5179	2.5189	2.5187	2.5191	2.5181	2.5183	2.5190	2.5185
2200.......	2.4962	2.4989	2.4982	2.4978	2.4970	2.4970	2.4965	2.4964
2300.......	2.5654	2.5675	2.5677	2.5674	2.5669	2.5667	2.5669	2.5661
2400.......	2.4940	2.4968	2.4960	2.4959	2.4949	2.4948	2.4953	2.4957
1900.......	2.5127	2.5138	2.5141	2.5140	2.5139	2.5134	2.5141	2.5130
2100.......	2.3812	2.3840	2.3839	2.3836	2.3831	2.3826	2.3828	2.3825
2200.......	2.5007	2.5036	2.5033	2.5029	2.5023	2.5021	2.5024	2.5016
2300.......	2.5305	2.5332	2.5331	2.5324	2.5321	2.5319	2.5319	2.5321

Table II

Steel 15. Length of Cylinders After the Heat Treatments Indicated

Quench temp. degrees Fahr.	Dimensions in inches							
	Original	As quenched	Drawn at 300 degrees Fahr.	Drawn at 500 degrees Fahr.	Drawn at 700 degrees Fahr.	Drawn at 900 degrees Fahr.	Drawn at 1100 degrees Fahr.	Annealed
1900.......	2.5211	2.5213	2.5216	2.5223	2.5222	2.5222	2.5223	2.5214
2100.......	2.5056	2.5076	2.5078	2.5081	2.5077	2.5074	2.5074	2.5064
2300.......	2.4951	2.4978	2.4976	2.4973	2.4966	2.4963	2.4977	2.4960
2000.......	2.4872	2.4900	2.4898	2.4897	2.4892	2.4888	2.4891	2.4886
2200.......	2.4951	2.4986	2.4980	2.4979	2.4970	2.4969	2.4984	2.4969
2300.......	2.5169	2.5205	2.5204	2.5193	2.5183	2.5181	2.5185	2.5176
2400.......	2.5107	2.5152	2.5147	2.5145	2.5130	2.5128	2.5134	2.5129
1900.......	2.4610	2.4639	2.4635	2.4634	2.4631	2.4626	2.4635	2.4612
2100.......	2.5084	2.5117	2.5114	2.5109	2.5103	2.5097	2.5102	2.5088
2200.......	2.4987	2.5020	2.5012	2.5003	2.5001	2.4996	2.5007	2.4990
2300.......	2.4967	2.5013	2.5012	2.5007	2.4999	2.4994	2.4997	2.4997

Table III

Steel 13. Length of Cylinders After The Heat Treatments Indicated

Quench temp. degrees Fahr.	Dimensions in inches							
	Original	As quenched	Drawn at 300 degrees Fahr.	Drawn at 500 degrees Fahr.	Drawn at 700 degrees Fahr.	Drawn at 900 degrees Fahr.	Drawn at 1100 degrees Fahr.	Annealed
1900.......	2.5185	2.5234	2.5231	2.5230	2.5225	2.5207	2.5205	2.5198
2100.......	2.4898	2.4920	2.4913	2.4936	2.4925	2.4917	2.4925	2.4894
2300.......	2.4406	2.4426	2.4419	2.4413	2.4428	2.4424	2.4433	2.4395
2000.......	2.5269	2.5301	2.5290	2.5291	2.5287	2.5284	2.5285	2.5261
2200.......	2.5175	2.5215	2.5210	2.5197	2.5195	2.5190	2.5201	2.5176
2300.......	2.5377	2.5414	2.5402	2.5398	2.5389	2.5385	2.5402	2.5382
2400.......	2.5432	2.5464	2.5452	2.5444	2.5435	2.5433	2.5454	2.5441
1900.......	2.4889	2.4916	2.4905	2.4901	2.4905	2.4898	2.4903	2.4872
2100.......	2.5128	2.5160	2.5149	2.5139	2.5143	2.5137	2.5144	2.5120
2200.......	2.5213	2.5242	2.5238	2.5233	2.5231	2.5225	2.5234	2.5214
2300.......	2.5022	2.5057	2.5045	2.5039	2.5030	2.5025	2.5045	2.5025

spectively. Examination of the table and the charts reveals that high speed steels of this type always expand in hardening. In general, up to a certain limit, the higher the hardening temperature the greater will be the expansion. When this hardened high speed steel is drawn, it contracts at temperatures up to 900 or 1000 degrees Fahr. When heated then at 1100 degrees Fahr. it expands and when finally heated at higher temperatures it contracts until it finally reaches approximately the original dimensions of the annealed condition.

Careful examination of the table will show that there is in some cases a notable variation in the amount of change of dimension. This is due partly to the fact that the earlier measurements were not so accurate as the later ones. However, these variations in dimension change are due

Fig. 1—Full size sketch of test specimen used

in probably greater degree to slight variations in the heat treatment. It seems likely that the time factor is the one which has the greatest effect on these variations. Greater concordance in individual results could undoubtedly have been obtained by timing all heat treating operations accurately, combined with greater care in the use of salt baths, but these refinements were purposely avoided. It was the desire to obtain average data which would show the order of magnitude of the changes to be expected when operating under average shop conditions. The charts are drawn to show the results likely to be obtained on the average, when treating steel under the conditions shown.

It will be observed that there is always an expansion on hardening; and that this expansion is greater, the higher the quenching temperature, up to a certain point. The subsequent contraction on heating up to 900 degrees Fahr. is also greater the higher the quenching temperature. This

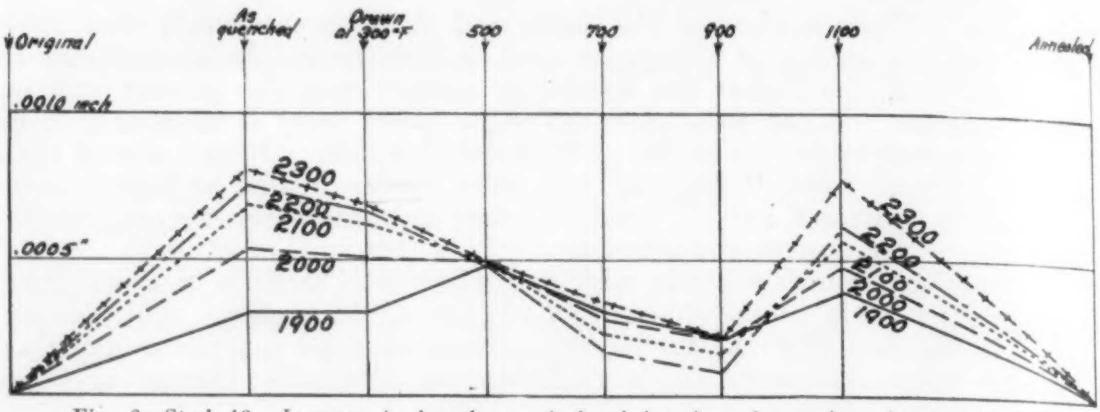

Fig. 2—Steel 18. Increase in length per inch of length under various heat treatments

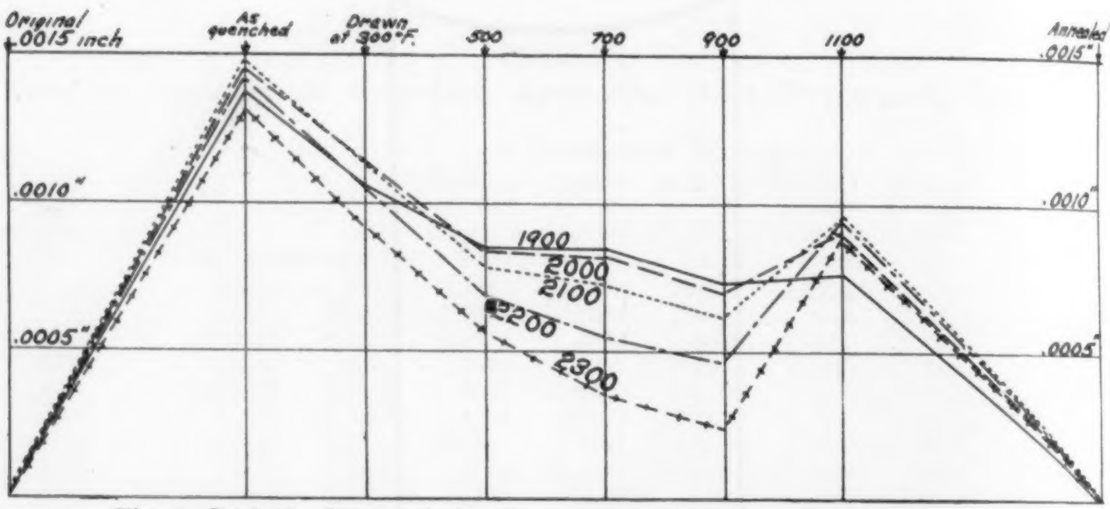

Fig. 3—Steel 15. Increase in length per inch of length under various heat treatments

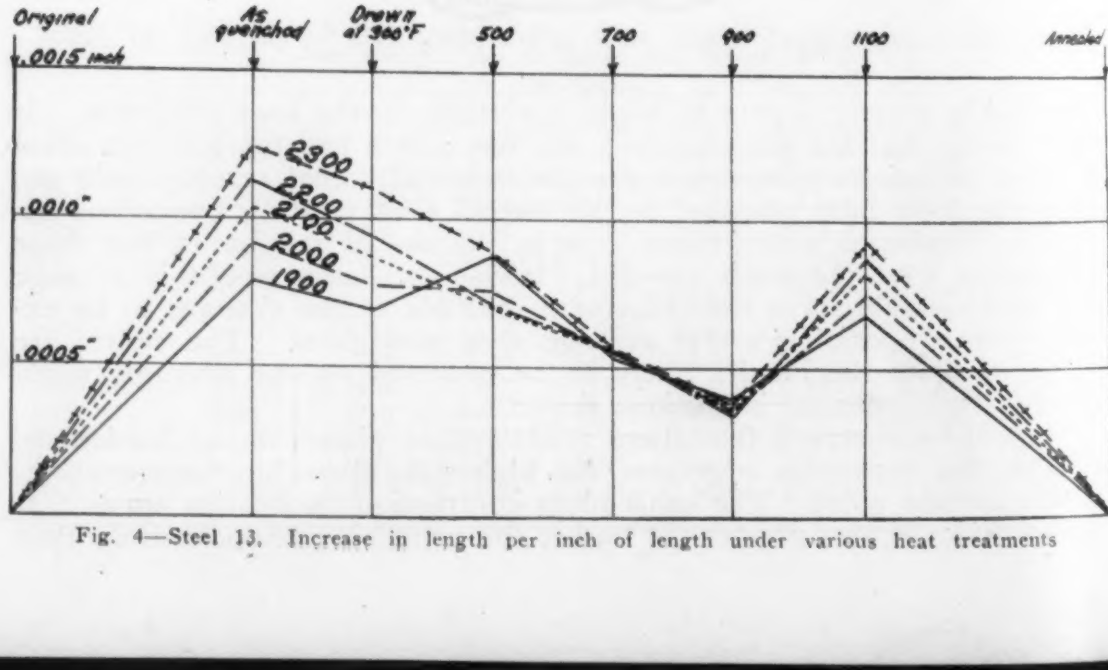

Fig. 4—Steel 13. Increase in length per inch of length under various heat treatments

is to be expected, as the original expansion has to do largely with the formation of one form of martensite. This martensite is changed by tempering, the resulting grain growth and formation of carbide being accompanied by contraction in volume. Then when the steel is heated at 1100 degrees Fahr., an expansion sets in, which is the index of the change from austenite to the second martensite. This, as was also to be expected, is more pronounced the higher the quenching temperature. With further drawing at still higher temperatures the steel contracts to about its former dimensions.

A comparison of the three steels, shows that the first expansion is greater in the lower tungsten steels, and that the second expansion, namely at 1100 degrees Fahr., is greater in the higher tungsten steels. A further important point is that while the lower tungsten steels can be heat treated to develop a reasonably large amount of austenite, the heating in the highest ranges causes overheating, coarse grain, and its accompanying brittleness with excessive blistering of the surface. The higher tungsten steels can be heated to temperatures high enough to develop a very considerable amount of austenite, and still retain a fine-grained structure with its accompanying advantages.

THE INFLUENCE OF HEAT TREATMENT UPON THE MAGNETIC PROPERTIES OF STEEL

By Lancelot W. Wild

MAGNETIC quantities that may be varied by subjecting steel to definite heat treatments may be classified as follows:

1. The intensity of magnetization under the influence of a magnetizing force sufficient to saturate the steel.

2. The permeability under one or more purely arbitrary magnetizing forces.

3. The residual induction on closed circuit, resulting from the application of any conveniently high magnetizing force.

4. The coercive force resulting from the application of a high magnetizing force.

Intensity of magnetization when the steel is fully saturated is a measure of the amount of magnetizable material in the steel. It can be measured with a high degree of precision on short cylindrical specimens and the measurements can be carried out very quickly.

Measurement of permeability, if it is to be measured with precision, requires the employment of specimens of ring form or else very long rods which must be tested in pairs. Rings require that they be wound for each test and the employment of long rods greatly increases the difficulty of carrying out precise heat treatment.

Measurement of residual magnetism is even more difficult than that of testing permeability. It is hardly possible to obtain precision except with ring specimens.

Coercive force can be measured on the same cylindrical specimens as are used for the measurement of intensity of magnetization. The testing can be carried out very quickly and a high degree of precision is obtainable.

In this paper the author has confined his attention to the measurement of intensity of magnetization and coercive force, the two tests being carried out on the same set of specimens. The object of the experiments was to obtain a general survey of the effects of reheating hardened steel to various temperatures and slowly cooling it.

The specimens consisted of cylinders 1 inch long and ¾ inch in diameter. The magnet for saturating the specimens was formed out of two discarded transformers. The magnet with the specimen in position is shown in section in Fig. 1. *a* is the specimen under test. *b* is the ballistic coils, of which more will be said later, *c* is a block of ebonite, into which the specimen is inserted. This insures that the specimen shall stand upright while the upper half of the magnet is being lifted on or off. *d* shows the winding of the magnets. *e* represents the two blocks of iron. These were made about 0.995 inches high in order that the weight of the upper half of the magnet should rest mainly upon the specimen so as to secure good magnetic contact. *f* represents the transformer laminations. The section of the core is 2 inches square, thus giving 4 square inches of pole surface.

The magnet was wound with 820 turns of copper wire of 0.080 inch diameter. With 12 amperes and about 20 volts a magnetizing force of $H = 4000$ was obtained. With 30 amperes H could be increased to 6000, but

A paper presented by title at the Indianapolis Convention. The author, Lancelot W. Wild, is president, Wild-Barfield Co., London, Eng.

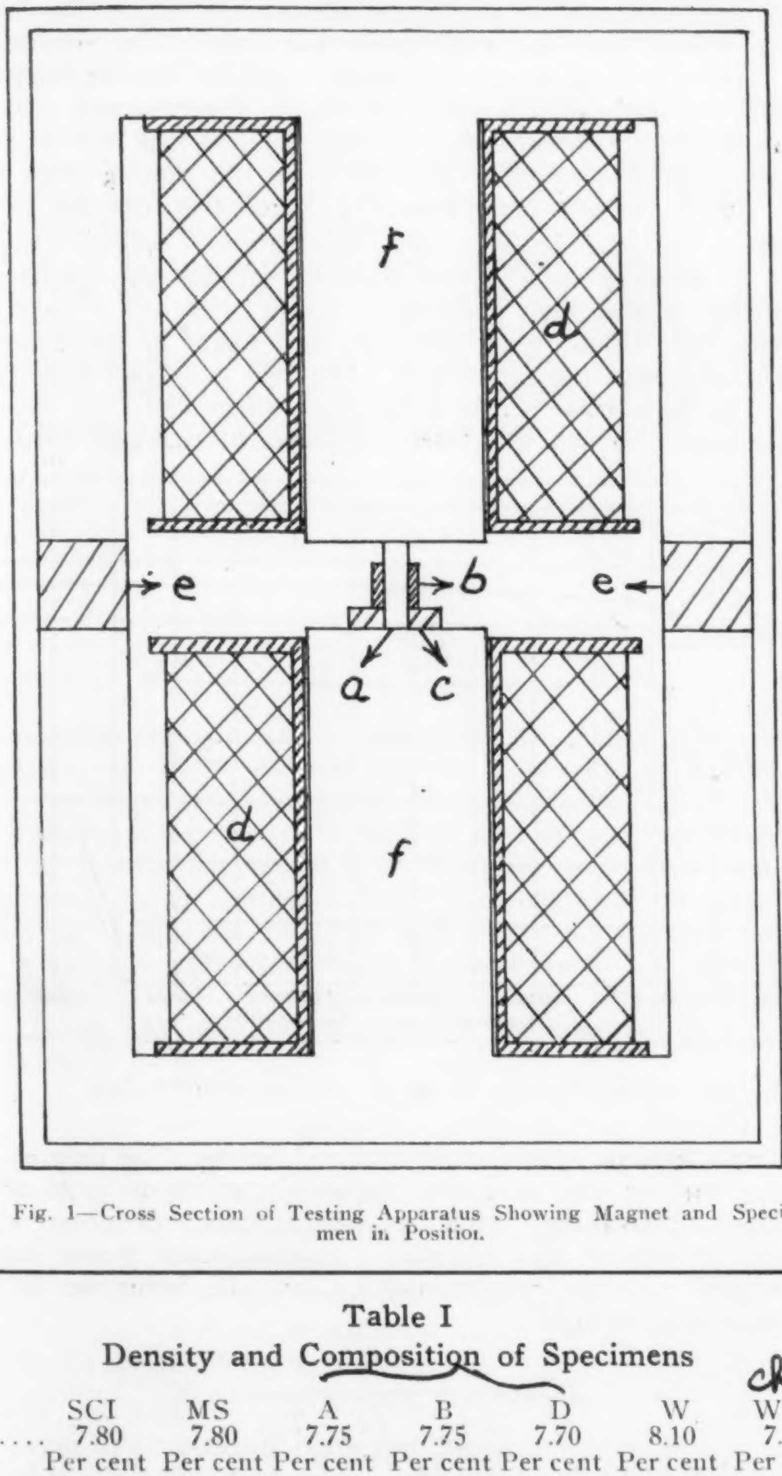

Fig. 1—Cross Section of Testing Apparatus Showing Magnet and Specimen in Position.

Table I
Density and Composition of Specimens

	SCI	MS	A	B	D	W	WPS	N
Density	7.80	7.80	7.75	7.75	7.70	8.10	7.52	7.75
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Carbon	0.03	0.12	0.63	0.91	1.03	0.86	1.24	0.42
Manganese ...	0.04	0.625	0.33	0.34	0.29	0.345	1.05	0.65
Tungsten	...	...	...	...	...	6.34	...	...
Chromium	...	...	...	...	...	...	10.6	...
Nickel	...	...	...	...	...	...	...	3.58
Silicon	0.01	...	0.094	0.094	...	...	...	...
Sulphur	0.013	...	0.008	0.017	...	...	...	...
Phosphorus ..	0.014	...	0.017	0.072	...	...	...	...

Chroma

owing to the heat produced it was found impossible to use this higher magnetizing force except for one experiment per day. The winding was not in any way endangered by using the larger current, but sufficient heat was soon communicated to the specimens to make a measurable drop in their saturation intensities. Fortunately, it was found that every steel tested was fully saturated at $H=3000$, and most of the testing was carried out at $H=4000$, under which conditions the specimens remained quite cool.

Arrangement of the ballistic coils the author believes to be novel. An inner coil of 40 turns was wound directly without any insulation beyond the silk covering of the wire itself in a single layer on a very thin brass tube. An outer coil wound with 18 turns and made in the same way was fitted concentrically onto the inner coil. The two coils had exactly the same area turns. The two coils were connected differentially in series with a ballistic galvanometer, which was scaled in terms of maxwell turns.

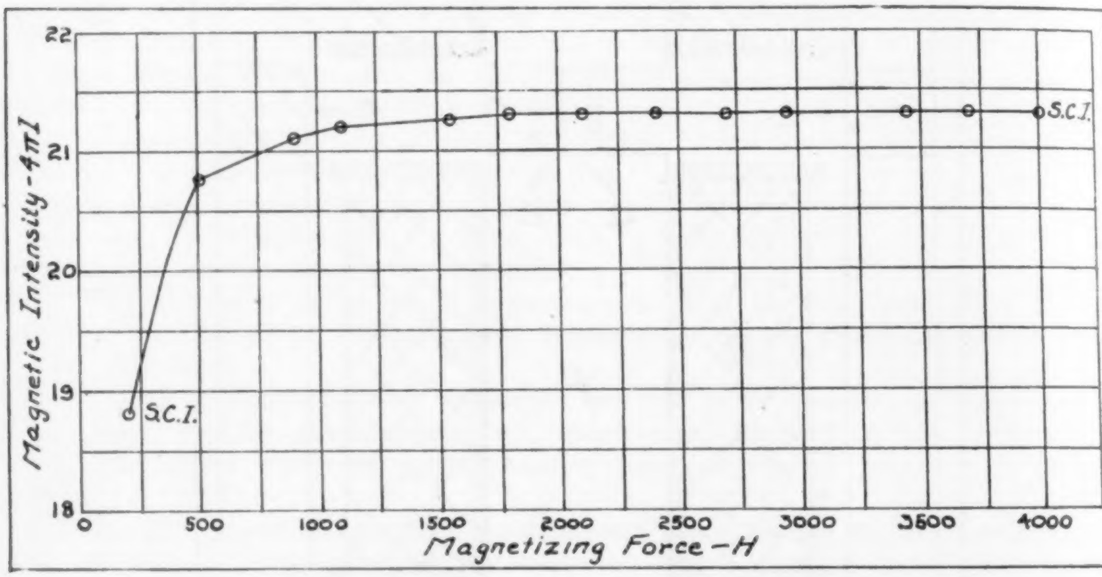

Fig. 2—Magnetization Curve for Swedish Charcoal Iron

When a brass dummy specimen was placed between the magnet poles and the magnetizing current was reversed, absolutely no throw was obtained on the galvanometer. However, when a magnetizable specimen was placed in position and the current was reversed a galvanometer throw was obtained which it is evident must be proportional to, not the induction in the specimen, but the magnetic intensity.

$$2\pi I = \frac{Mt}{2A \times (T_1 - T_2)}$$

Where I is the magnetic intensity.
A is the area of the specimen.
T_1 is the number of turns on the inner coil.
T_2 is the number of turns on the outer coil.
Mt is maxwell turns.

Two advantages are found in using this differential arrangement. In the first place, it is not necessary to maintain the current steady. In the second place a higher precision is obtainable by taking a single throw instead

of the more usual plan of taking one reading on the inner coil and subtracting from this an amount calculated from a reading taken with the two coils connected differentially.

To obtain the value of H, which however was never required with exactness, a throw was taken on the outer coil alone and from this was subtracted an amount derived from the ordinary differential throw by multiplying it by 18 and dividing by 22, the ratio of the turns on the outer coil to the effective differential turns.

Fig. 2 shows the magnetization curve obtained with a very pure Swedish charcoal iron (SCI). The density of this iron was 7.80. It will be seen that saturation is attained at about $H=1800$, and that above this value the magnetic intensity remains constant. The saturation value of $4\pi I$ is 21.3 kilo lines per square centimeter and I itself is therefore 1695.

The following values have been found previously:

Authority	Year	Value of I
Ewing and Low	1889	1630-1740
Du Bois	1890	1700-1725
Gumlich	1909	1725
Peirce	1909	1740
Beattie	1910	1740
Wild	1910	1695-1710
Hopkinson	1911	1680
Cheney	1920	1672-1725

The variation in the above authorities is remarkable. No doubt this is partly due to errors of method and of instrument calibration, but is also no doubt very largely due to variations of density and to slag inclusions.

The coercive force was measured on the same specimen pieces as were used for the saturation intensity test. The procedure was as follows: After magnetizing the specimen, the upper half of the magnet was lifted off and the specimen was removed and placed in a small search coil connected to a ballistic coil of suitable sensitiveness. The specimen was then sharply withdrawn and the galvanometer throw was observed. This gave the open circuit remanance from which the coercive force could be calculated directly.[1]

$$Hd = \frac{Mt}{4\pi AT} \times D$$

Where B=flux density.
A=area of specimen in square centimeters.
Mt=maxwell turns.
T=number of turns on search coil.
Hd=demagnetizing force due to ends.
Hc=coercive force.
D=demagnetizing coefficient.

The value of D depends upon the dimension ratio that is length to diameter. In this case the dimension ratio was 4. The value for D for this dimension ratio is given by Professor Thompson[2] as 0.724.

Now Hc must be more than Hd or there would be no open circuit remanance. For a specimen having a dimension ratio of 4 a cursory in-

1. L. W. Wild. "A Method of Measuring the Magnetic Hardness of Ferrous Metals and Its Utility for Carrying Out Research Work on Thermal Treatment." Transactions of the Farraday Society. Vol. 15, Part 3.

2. Silvanus Thompson. "The Magnetism of Permanent Magnets." Journal of the Institution of Electrical Engineers. Vol. 50. No. 217.

coercive force demag.

spection of a hysteresis loop shows that the ratio of Hc to Hd must be something less than 1.05. Experiments on tungsten steel have determined this ratio to be 1.02 with an uncertainty of about 0.01 either way. This is quite near enough for the measurement of coercive force, for heat treatment experiments, especially as relative rather than absolute values are required.

Experiments were carried out on iron and ~~7~~ 6 different steels. The analyses and density of these is given in Table I. The specimens were first heated and quenched from the following temperatures:

S.C.I.—Swedish charcoal iron. 910 degrees Cent.

M.S.—Common mild steel. 860 degrees Cent.

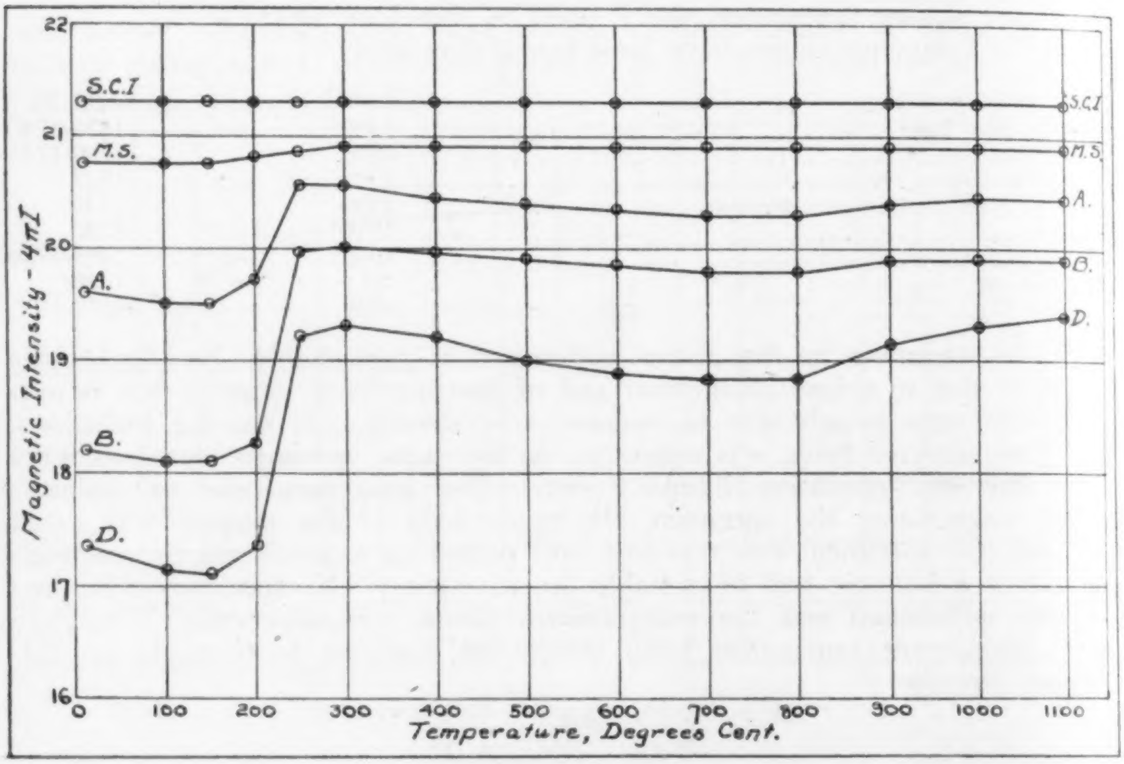

Fig. 3—Magnetic Intensity Curves for Swedish Charcoal Iron, Common Mild Steel, and Straight Carbon Steels

A, B, and D.—Straight carbon steels. When just nonmagnetic.

W. and W.P.S.—Tungsten and chrome steels respectively. 850 degrees Cent.

N.—Nickel steel. When just nonmagnetic.

After being quenched the specimens had 24 hours rest before being tested for saturation intensity and coercive force. The specimens were then subjected to the following successive heat treatments being tested after each when quite cold.

1. Boiled in water for 5 hours.
2. Heated in oil and maintained at 150 degrees Cent. for 30 minutes.
3. Heated in oil and maintaianed at 200 degrees Cent. for 5 minutes.
4. Heated to 250, 300 and 400 degrees Cent. successively in a mixture of potassium and sodium nitrates.
5. Heated in furnace in an atmosphere of pure hydrogen to temperatures of 500, 600, 700, 800, 900, 1000 and 1100 degrees Cent. They were

cooled down in the furnace to 400 degrees Cent. and were then removed and finished in air.

Table II gives all the values of magnetic intensity and Table III those of coercive force. Curves from these tables have been plotted and are to be

Table II
Values of Magnetic Intensity*

Reheating temperature degrees Cent.	SCI	MS	A	B	D	W	WPS	N
None	21.3	20.75	19.6	18.2	17.35	18.45	14.25	20.7
100	21.3	20.75	19.5	18.1	17.15	18.45	14.2	20.7
150	21.3	20.75	19.5	18.1	17.1	18.45	14.2	20.7
200	21.3	20.8	19.7	18.25	17.35	18.5	14.25	20.75
250	21.3	20.85	20.55	19.95	19.2	19.15	14.3	20.8
300	21.3	20.9	20.55	20.0	19.3	19.3	14.35	20.9
400	21.3	20.9	20.45	19.95	19.2	19.3	14.35	20.8
500	21.3	20.9	20.4	19.9	19.0	19.2	14.35	20.75
600	21.3	20.9	20.35	19.85	18.9	19.15	14.35	20.7
700	21.3	20.9	20.3	19.8	18.85	19.15	14.35	20.6
800	21.3	20.9	20.3	19.8	18.85	19.25	14.35	20.55
900	21.3	20.9	20.4	19.9	19.15	19.6	14.45	20.7
1000	21.3	20.9	20.45	19.9	19.3	19.4	14.4	20.75
1100	21.3	20.9	20.45	19.9	19.4	19.15	14.35	20.75

*Specimens heated and quenched from best hardening temperature, then reheated to following temperatures and slowly cooled. $4\pi I$ tested when quite cold.

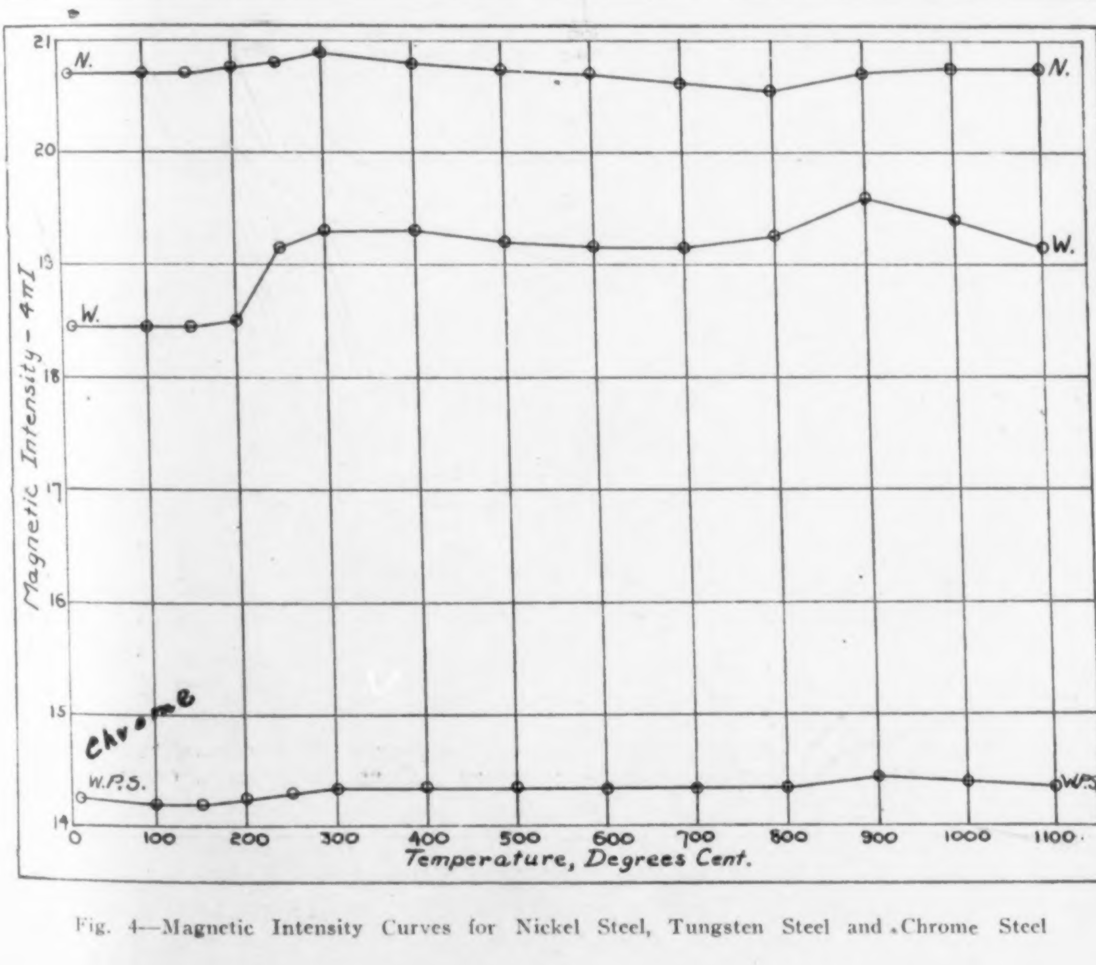

Fig. 4—Magnetic Intensity Curves for Nickel Steel, Tungsten Steel and Chrome Steel

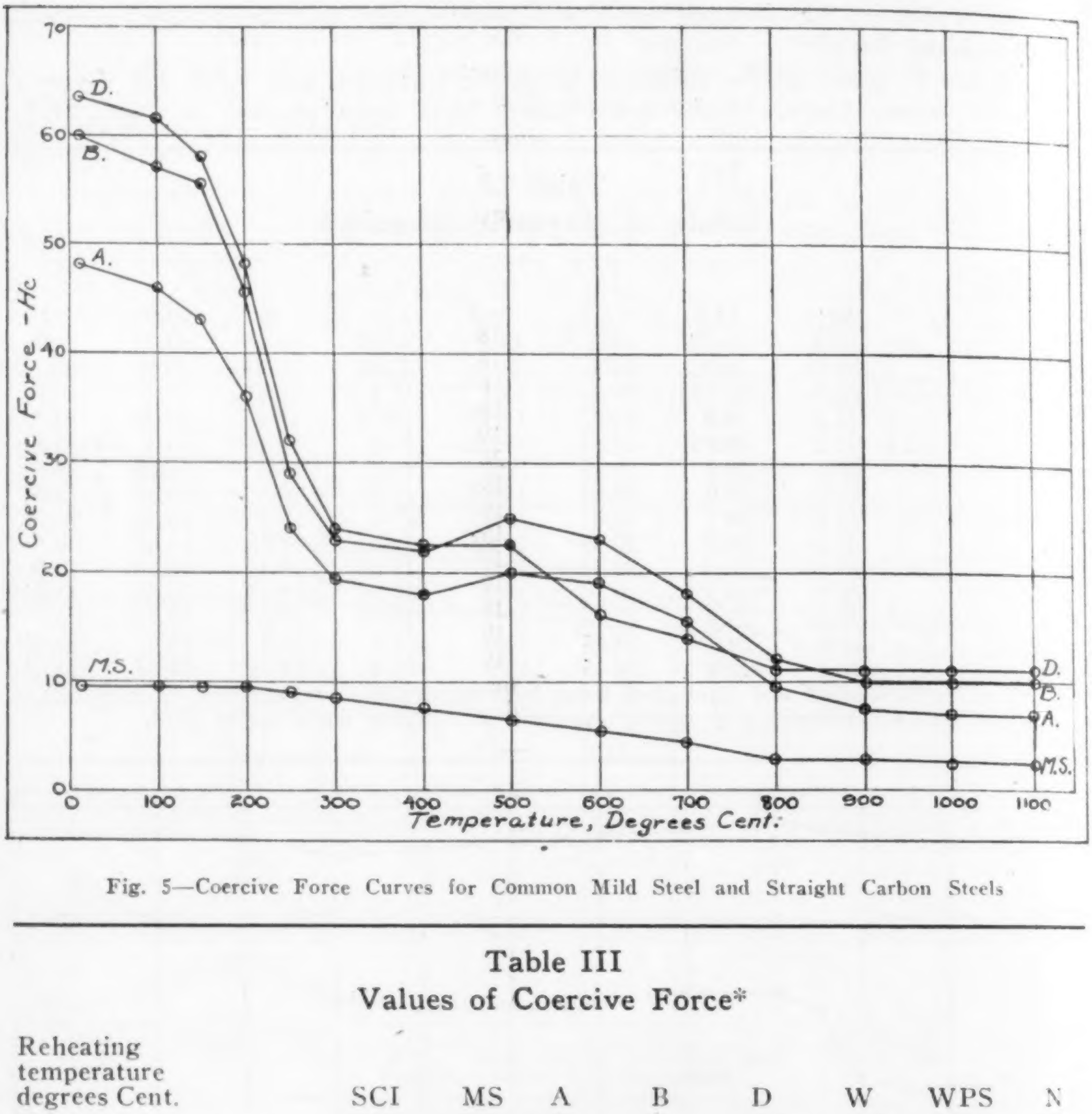

Fig. 5—Coercive Force Curves for Common Mild Steel and Straight Carbon Steels

Table III
Values of Coercive Force*

Reheating temperature degrees Cent.	SCI	MS	A	B	D	W	WPS	N
None	1.5	9.5	48	60	63.5	61.5	48.5	24
100	1.5	9.5	46	57	61.5	58	48	23
150	1.5	9.5	43	55.5	58	55	47	22
200	1.5	9.5	36	45.5	48	45	45	21
250	1.5	9	24	29	32	33	43	18.5
300	1.5	8.5	19.5	23	24	26	40	15.5
400	1.5	7.5	18	22	22.5	24.5	37	13.5
500	1.5	6.5	20	25	22.5	23	26	10
600	1.5	5.5	19	23	16	24.5	17	9
700	1.25	4.5	15.5	18	13	20	15	10.5
800	1.0	3	9.5	12	11	16	14.5	8.5
900	1.0	3	7.5	10	11	15	14.5	7.5
1000	0.75	2.5	7	10	11	21	22	7
1100	0.75	2.5	7	10	11	27	30	7

*Specimens heated and quenched from best hardening temperature, then reheated to following temperatures and slowly cooled. Coercive force measured when quite cold.

found in Figs. 3 to 6. It will be seen that the saturation intensity of iron remains quite unaffected by heat treatment, though the coercive force de-

clines as soon as hardening strains are taken out and still further as grain growth commences.

The galvanometer employed was not sufficiently sensitive to bring out the changes that really occur in the coercive force of iron. This might advantageously form the subject of a separate investigation. The addition of carbon lowers the saturation intensity all along the line. but there does not appear to be a directly linear relationship between the magnetic intensity and the carbon content. The most notable feature of the carbon steels is the rise of magnetic intensity between 200 and 300 degrees Cent., when the cementite is precipitated from solution.

The small drop of magnetic intensity on reheating to 100 or 150 de-

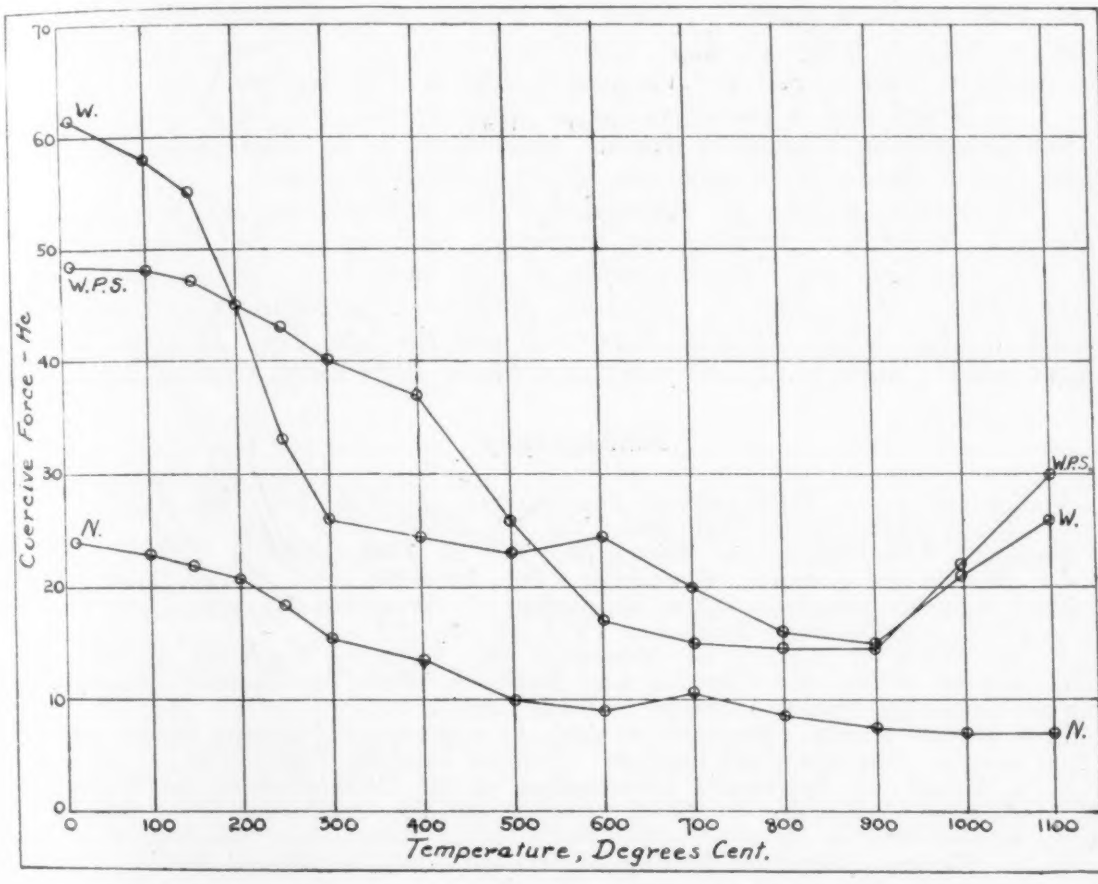

Fig. 6—Coercive Force Curves for Chrome Steel, Tungsten Steel and Nickel Steel

grees Cent. the author is unable to explain. On reheating to a temperature of 400 to 800 degrees Cent., apparently some of the cementite returns into solution and does not entirely reprecipitate with slow cooling. On reheating to 1000 degrees Cent. or more when all cementite must be in solution, apparently all precipitates on slow cooling.

Referring to Fig. 5, it will be seen that there is a very large drop of coercive force taking place between 200 and 300 degrees Cent. Doubtless, this is due to the cementite coming out of solution and thereby becoming magnetic. The peculiar hump at a temperature of 500 degrees Cent. is of interest. This may be due to the cementite again partially entering solution and not precipitating on cooling as previously suggested.

Coming to the three alloy steels, it will be seen that the nickel steel

behaves in very much the same way as a carbon steel. The nickel however which, when in a free state is only about one-third as magnetic as iron, becomes about equivalent to iron when alloyed with it. The tungsten steel follows the general line of a carbon steel except that the carbon features are less pronounced and there is a decided drop of magnetic intensity and increase of coercive force when a reheating temperature of 900 degrees Cent. is exceeded.

The chrome steel is most remarkable. It contains 87 per cent of iron and yet the saturation intensity is only about 67 per cent of pure iron, and this remains almost untirely unchanged by heat treatment. The coercive force does not drop on tempering nearly so steeply as with other steels, and the rise on heating to over 900 degrees Cent. is even more pronounced than with tungsten steels. It will be noticed that all three alloys steels show a distinct hump in their coercive forces, the chrome steel at 400, the tungsten steel at 600 and the nickel steel at 700 degrees Cent.

It is hoped that a consideration of these results will be of some value to metallurgists in coming to definite conclusions as to what really happens when steel is hardened or otherwise given thermal treatment.

The author wishes to acknowledge his indebtedness to his brother Roland C. Wild for carrying out numerous analyses, to Sir Robert Hadfield for supplying him with a sample of very pure iron and for taking an interest in the work, and to numerous previous experimenters and writers, notably the late Prof. Silvanus Thompson and the late Prof. Bertram Hopkinson, who by their work and publications have done much to clear the way.

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THE CARBONIZING PROCESS—RELATION OF TIME AND TEMPERATURE TO DEPTH OF CASE

By Theodore G. Selleck

THE time factor of the carbonizing process is one that depends upon so many conditions outside of itself that it really seems under most circumstances to be incidental to the process, rather than a positive, predetermined factor. Of course all action of whatever sort is measured and usually more or less governed by time. In most chemical and mechanical processes this factor is thoroughly understood and is given a scientific basis of value; but in the carbonizing process we find it difficult to establish its value because such value depends upon so many conditions which, so far, we have not been able to even standardize approximately.

First of all in carbonizing, the time required to produce a certain depth of case will depend upon the degree of temperature at which the operation is carried out. To the average case hardener this settles the whole question of the function of time. He is convinced that if he gives his work 100 per cent more time he will much more than double the depth of penetration without increasing the temperature. If he could maintain the same conditions for the extended time that prevailed during the shorter period, his conclusions probably would prove quite true, and oftentimes this occurs. Again he may be surprised to find that his conclusions are all wrong, and that he has not added to depth of case to any material extent by giving added time. In some cases he really loses in the quality of the case. This is because time, as an element of the process, depends not only upon temperature but upon every other element or factor of the process and the conditions of those elements and factors. Some of them are exceedingly variable, changing during the progress of the operation without giving the operator any evidence of change until he finds it in the final result.

Carburizing materials sometimes change their chemical compositions materially during protracted periods of heating, and the operator has no knowledge of a change until he finds no increase of penetration. Probably he finds also that the carbon content of the case is lower than he has been in the habit of obtaining in the shorter operations.

This sometimes occurs where an operator has used one carburizer, perhaps for years, on a certain line of work requiring only short time periods and he has found it to work satisfactorily and consistently at a certain temperature for a certain period of time. Suddenly he changes his time schedules, or his temperature, and finds that either the added time or the increased temperature have brought about chemical changes in his carburizer that he did not anticipate.

It is not unusual either for one user of a carburizer to obtain greater depth of case than another user of the same carburizer, when used for the same period of time, at the same temperature, on the same type of steel and on the same character of parts. In the one case the operator may be getting as much as 1/16-inch penetration in 6 hours at 1650 degrees Fahr., while his neighbor may be getting but 1/32-inch in the same time and at the same temperature. The governing conditions in such cases may be in the difference in the methods of packing the parts in the boxes,

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or pots, or the placing of the boxes, or pots in the furnace. These are some of the variables of the process which affect directly the value of time in the process and make it difficult to establish standard schedules, or to find the true relation of time to temperature in carbonizing steel. It would not be difficult for us to find the exact relation of time to temperature could we always be sure that we had the exact temperature the pyrometer indicated. If we knew exactly the carbon content, the percentage of other alloys in the metal; and could be sure of the constancy of the carburizer. These "ifs" form a barrier that we have been unable to remove by any method of operation that has been developed to the present time. Therefore it is only in a general way can we consider the relation of these two factors of the process to each other, and to the results to be obtained in the application of the process.

As a matter of fact there is no element of time in the carburization

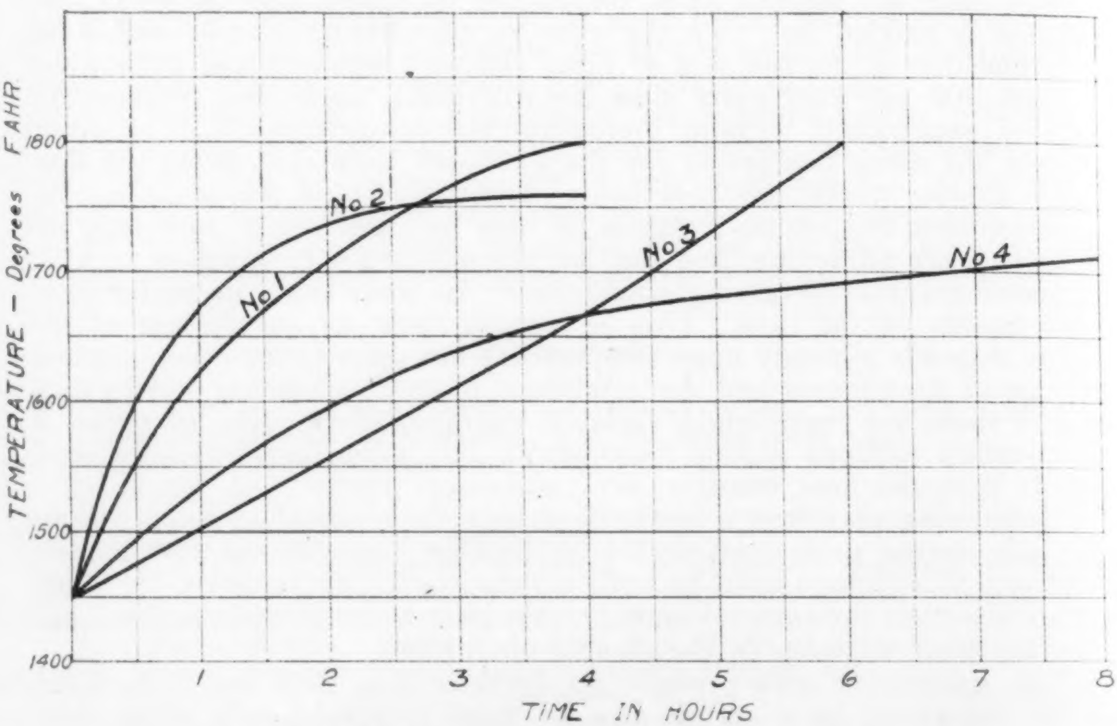

Fig. 1—Chart showing carbon penetration with relation to time and temperature

of iron, when the metal has been brought to the proper thermal condition and the carbon is simultaneously in the proper condition for the iron to accept it. The carburization is instantaneous under such conditions, although its permanency may depend upon conditions that are difficult, if not impossible to establish.

The writer has seen numerous examples of steel castings carbonized by the use of a "carbonizing core" during the pouring of the metal; and it is quite possible to obtain considerable depth of case by this method. However, the difficulty lies in preventing the "burning out of the carbon" during the pouring operation. But it is evident that the carburization must be instantaneous. T. E. Worley, of the American Steel Foundries Co., of Hammond, Ind., has made some very interesting experiments along the line of carbonizing steel castings in the pouring of them.

Another method of proving the instantaneous action of carburization

is to heat the metal to a temperature well beyond its critical point and to cover it with such carbonaceous materials as charred leather, charcoal, barium, etc., all finely powdered. A high carbon content is obtained in this manner, and because of the fact that the temperature of the metal falls rapidly and is below the carbonizing temperature within a few minutes, the carburization must be instantaneous. The element of time therefore applies only to the travel of the carbon from the surface of the metal toward the center or core. This travel depends upon (1) temperature, (2) character of the metal, (3) the nature and constancy of the carburizer.

Some years ago the writer made some experiments to determine the exact relation of temperature, or rather heat, to the absorption of carbon in the carbonizing process. The theory upon which these experiments were based, was that the same number of heat units passing through steel surrounded by carbonaceous material and at a temperature above the carbonizing point of the steel, should always produce the same result, regardless of the time involved in the operation. Several tests were made and charted, but unfortunately the experiments were never carried to a conclusion, although some data of value was obtained.

In the making of these tests to establish, what the writer has called a "thermo-volumetric scale" of heat values, various curves were made of carbonizing operations carried on always at rising temperatures, never at certain temperatures for a definite time period. These curves and the results obtained in their making were compared from the standpoint of the number of the heat units used in their development. One of the charts is shown in Fig. 1. Curves No. 1 and 2 show the same penetration for the same time period, although temperature conditions were different for the two tests during the operation. The same result, so far as depth of case, was obtained in the making of curves No. 3 and 4, although No. 4 had the highest temperature for the first three hours and was given the advantage of two more hours of heat. The number of heat units cannot be stated because the records of these experiments have been lost. But it will be noticed that no record is made of the heat involved below the minimum carbonizing temperature of 1470 degrees Fahr.

In a positive manner these results seem to establish the relation of time to temperature to be the same as indicated in Fig. 2, wherein a graphic illustration of the difference in the value of the two factors is shown. This chart was made from tests of carburizing operations carried on for stated periods under temperature and carburizer conditions as constant as possible. The same carburizer was used, the same type and size of steel test pieces were used, the same alloy container was used, and the same furnace and pyrometer used in all the tests. An interesting, and valuable chart could be developed by carrying this line of experiments further, but from this chart it will be seen that a few more degrees of temperature is vastly more potent in producing depth of case than several hours time. According to this chart the line of tests run at 1700 degrees Fahr. gave the following depths of penetration for the periods of time mentioned:

Carburizing Time hours	Depth of Penetration Inches	Increase Per cent
2.5	$\frac{1}{64}$	100
5	$\frac{1}{32}$	-
8	$\frac{1}{16}$	100
10	$\frac{5}{64}$	25
12	$\frac{7}{64}$	40

At a temperature of 1750 degrees Fahr. a penetration of 5/64-inch was obtained in six hours, as against 10 hours for the lower temperature, whereby it is seen that the potency of 50 degrees above 1700 degrees Fahr. is equal to four hours at 1700 degrees Fahr. The vertical line on the chart indicating a series of tests carried for a period of six hours at various temperatures indicates that 1/32-inch penetration was obtained in six hours at 1600 degrees Fahr. whereas the horizontal line shows that the same depth of case was produced in five hours at 1700 degrees Fahr.

From these charts we learn that if all desired is heavy penetration we have only to carbonize at a high temperature, but it is a foolhardy case hardener who adopts that method without determining first of all the carbonizing efficiency of his steel before attempting to establish time schedules. Facts concerning the carbonizing efficiency of the various alloys added to steel were given in the last paper of this series, published in the August, 1921, issue of TRANSACTIONS, therefore the matter will not be taken up here.

It has been stated that the travel of carbon into the steel from the surface toward the core, depended upon three conditions, the first of which has been discussed. However, it may be said in addition, that for the best

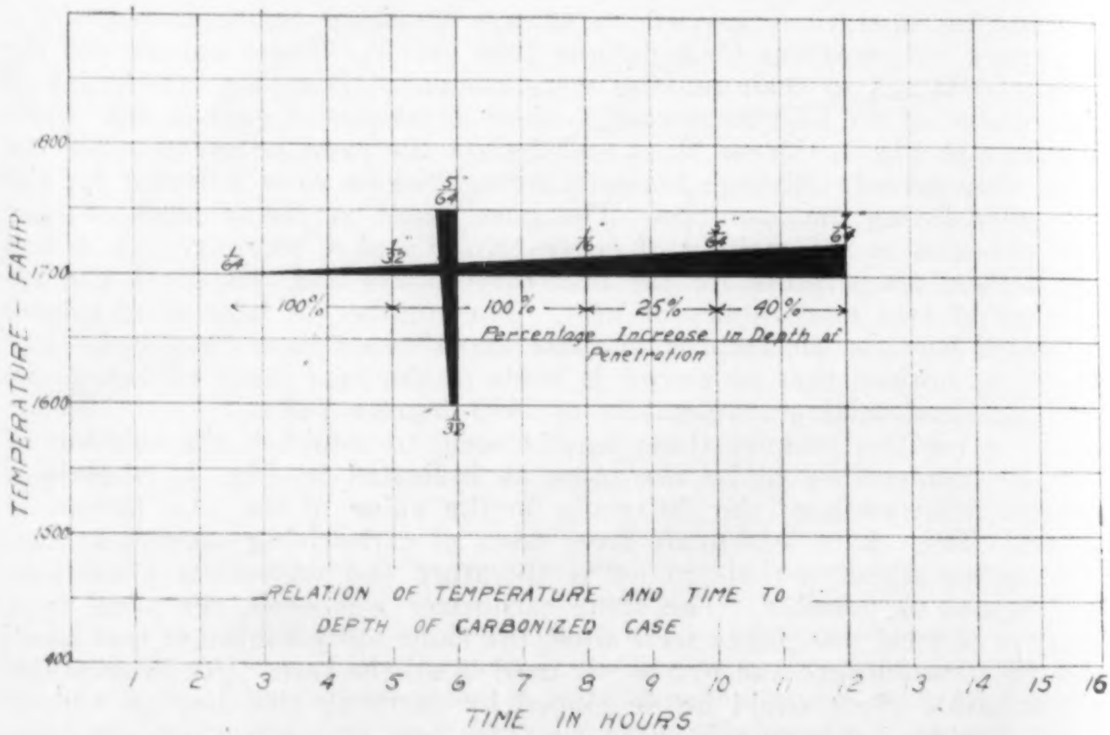

Fig. 2—Chart showing relation of temperature and time to depth of case

results in carbonizing, it is better to have a rising temperature throughout the operation than to have the temperature drop at any time even for a brief period, as such a drop of temperature, if of any consequence, will affect materially the diffusion of the carbon. Further light has been thrown upon the case mentioned in the August, 1921, issue of TRANSACTIONS concerning the plug gages that spalled severely when quenched from the pot. It seems that analysis of the scale from these gages showed a carbon content far beyond the theoretical capacity of the metal to absorb carbon, and that during the process of carbonizing, a severe

drop of temperature occurred which interfered with the natural diffusion of the carbon into the metal.

Character of the steel placed in the hands of the case hardener is at times only approximately known to him and as a result he is frequently the victim of circumstances. In the regular run of business in the treating of standard parts it is possible for him to know closely the analysis of his metal and accordingly he should be able to judge whether higher temperature or longer time is best for any added penetration desired. He may be assured that under all conditions of metal the higher the temperature the more rapid will be the penetration, but the good workman will know whether it is wise to use it.

As every case hardener should know the character and the carbonizing efficiency of the steel he treats, he should also know the efficiency of his carburizer. He should know, by personal experience, and not by the claims of the salesman or manufacturer whether it is of a character that will remain constant during long hours of service, or whether it has a limit beyond which it will not be efficient and economical. In determining these matters he should not take others word for it, not even the laboratory of his own plant, because no manufacturer knows as he does the exact conditions under which he is working, and laboratory conditions are rarely those of the furnace room. The man on the job is the one who above all others should know his equipment, his tools, his help, his supplies and his results better than anyone else, and the knowledge he gains from actual test and experiment is more valuable than he can gain by advice from metallurgist, salesman, or even by reading these articles, provided he is broad enough to take the best that is offered him by these agencies and add them to his own personal experiences to profit thereby.

DETERMINATION OF HEAT TREATING COSTS

By Harold F. Wood

DURING the past few years we have been passing through a period of large production and of general industrial waste. This has resulted in but little attention being paid to the question of costs. As long as there was a demand for the products, the main item of consideration was how to produce more. This resulted in a decrease in the efficiency of labor and a general increase in the amount of avoidable waste. Such a policy on the part of industrial managers created wasteful ideas not only on the part of labor but also on the managers themselves.

In those days the cost department served as a tool to collect unreliable data from which to secure figures to convince the customer that he should pay more for his product rather than to collect accurate data to convince the shop that the cost of production was excessive.

We have this past year been passing through a period of industrial depression. According to the opinion of our best business experts, we are now just entering a period of industrial readjustment which, in turn, will be followed by a period of general business prosperity. Just how soon this period of prosperity will arrive and how prosperous it will be, will be determined by how long it takes everyone connected with business to readjust themselves to the new conditions and get away from their wasteful and costly methods employed during our recent production period.

The industrial concern that realizes these facts and that knows accurate costs of every detail making up the final cost of its product will be the concern that will survive and prosper. Its motto will be "How to produce the most and the best for the least." This paper will not attempt to discuss how to produce the "most and the best" but will show in detail the items to be considered in the determination of an accurate unit cost and how these various items are embodied in the final cost which in turn tells us whether we are producing the "most and best for the least."

The heat treating department has come into its own and its operations of today constitute an important item in the cost of the finished product. There is no department in industry today that is more mysterious from a cost standpoint than that of heat treating. This has been caused by the fact that most industrial managers have only a very small idea of what heat treating really is and also by the fact that the science of metallurgy has developed so fast that the question of costs has been neglected.

One of the most important items in cost determination in the heat treating department is the proper distribution of the departmental burden on the various units of the department so that each one will bear its proper share. For the average heat treating department, the principal elements that constitute burden are fixed charges; which include the interest on investment in land, buildings, equipment and inventories, the real and personal property taxes, depreciation and repairs of buildings and equipment; indirect operating expenses such as supervision, indirect labor and

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supplies (including coal and water) fuel or electric power, and miscellaneous manufacturing expenses such as employees liability insurance, etc.

The distribution of burden is brought about by the creation of various burden centers in the heat treating department. For instance, if a heat treating department is made up of four electric furnaces of the same construction and size, and 10 oil fired furnaces of the same construction and size, there would be two burden centers. However, if part of the furnaces are of different design and construction it is necessary to have more burden centers to enable accurate costs to be determined on each individual unit.

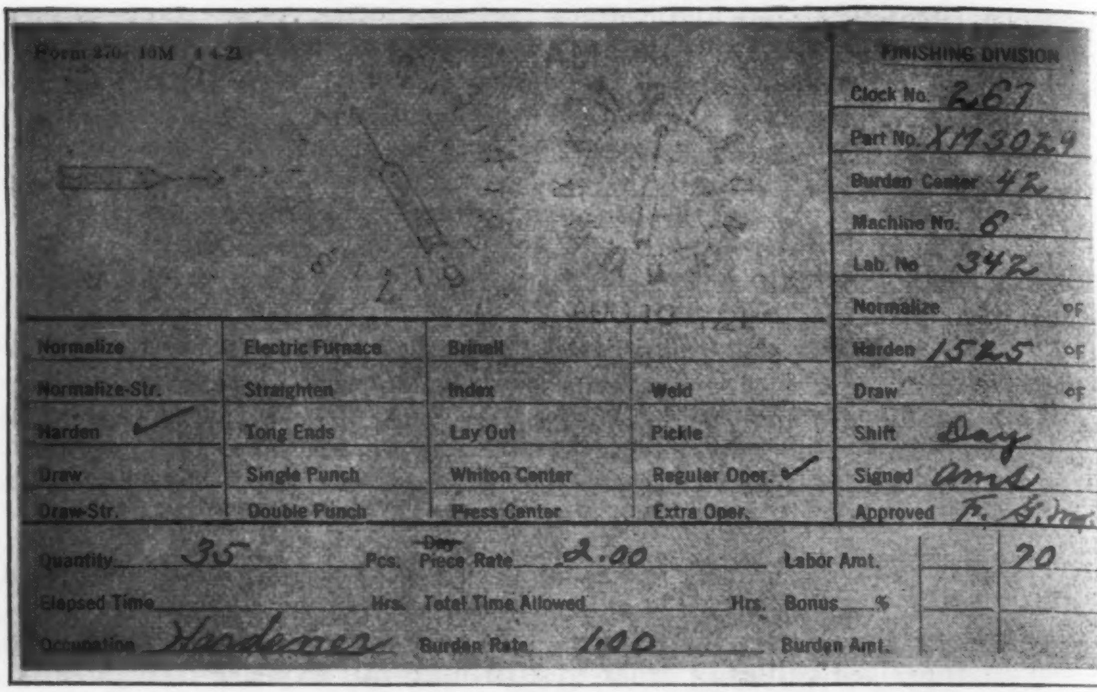
Interest—To determine the proper charge to each center for the use of equipment and in order to show the relation between the cost in centers equipped with expensive furnaces and those equipped with less expensive furnaces, interest at 5 per cent per annum on the investment in plant and inventory should be included as part of the burden. It might be said in passing that interest is an item that is neglected in many big companies today.

Taxes—State and county taxes on real and personal property should be included in the burden. Inasmuch as these taxes are levied on the assessed rather than appraised values, it is necessary to recalculate a rate based on appraised values in order to distribute this expense conveniently.

Depreciation and Repairs—The rates used in determining the amount of depreciation and repairs to be included in burden for cost purposes depends upon the design and construction of the particular furnaces making up the center in question. It has been the experience of the writer that a depreciation and repair rate of 10 per cent on well built electric and 15 per cent on well built oil furnaces is accurate. These rates depend to such a large extent on how the equipment is handled that it is impossible to estimate within plus or minus 2 per cent.

It is necessary to treat repairs as a fixed charge making the amount charged to cost on account of repairs uniform each month instead of showing a large fluctuation as would be the case if actual expenses were charged to cast as incurred. In connection with the depreciation and repair item the author desires to make the additional statement that a large number of companies that do keep accurate cost information make a mistake on the question of depreciation and repairs, because they consider by their experience that the repair rate over a period of time is so low that to charge off 15 per cent would be throwing too much of an extra burden on the furnace. They must take into consideration that with the strides that have been made in the past years in furnace design, the development of a furnace that is the last word today, is obsolete in about seven years. In other words, we must consider that a furnace must be either completely rebuilt or probably be completely replaced by a more modern furnace at the expiration of a period of seven years, so that would be about the maximum time that we should safely take in charging off the valuation of a furnace.

Land and Buildings Factor—The fixed charge on land is calculated by taking the sum of the interest and taxes of the land in question and dividing same by the land area in square feet. The fixed charge on buildings is calculated by taking the sum of the interest, taxes, depreciation and repairs on the building in question and dividing same by the building area in square feet. The rate on depreciation and repairs for heat


Form 270 10M 1-4-21

FINISHING DIVISION
Clock No. 267
Part No. XM3029
Burden Center 42
Machine No. 6
Lab. No 342
Normalize °F
Harden 1525 °F
Draw °F
Shift Day
Signed ams
Approved F. G. M.

Normalize	Electric Furnace	Brinell	
Normalize-Str.	Straighten	Index	Weld
Harden ✓	Tong Ends	Lay Out	Pickle
Draw	Single Punch	Whiton Center	Regular Oper. ✓
Draw-Str.	Double Punch	Press Center	Extra Oper.

Quantity 35 Pcs. ~~Day~~ Piece Rate 2.00 Labor Amt. 70
Elapsed Time Hrs. Total Time Allowed Hrs. Bonus %
Occupation Hardener Burden Rate 1.00 Burden Amt.

Fig. 1—Productive labor ticket which shows the particular operation being performed and whether it is regular or extra

treating buildings depends upon their type of construction. For a well-built fire-proof building this rate is approximately 3 per cent. The fixed charge per square foot on land and buildings is the sum of the above two items.

The floor area of the entire heat treating department is distributed over the various burden centers in proportion to the exact area occupied by the various centers. The land and buildings factor for each burden center is the product of the fixed charge per square foot on land and buildings and the area in square feet of the particular center in question.

Equipment Factor—The fixed charge on equipment in a given center is determined by the product of the equipment valuation and the rates for interest, taxes, depreciation and repairs. The sum of these charges represents the total equipment factor.

Indirect Labor—Indirect labor in the heat treating department includes supervision, clerks, inspectors, truckers, janitors, timekeepers, allowances to piece workers, etc. The amount chargeable to burden is determined by estimate for a period of a year and distributed over the various burden centers of the heat treating department in a way that in the opinion of the superintendent is evenly divided.

Supplies—Certain materials are required in the operation of each center which do not enter directly into the products of that center. These include oil waste and grease, small tools, paint, water, coal, first aid supplies, disinfectants, electric power for lighting and operating cranes, but not for furnace heating, etc.

Power and Fuel—This covers the amount of fuel oil in the case of oil-fired furnaces or of electric power in the case of electric furnaces. The amount taken for each center is based upon the estimated tonnage to be treated and the hours to be worked for the year.

General Factory Burden—To be included in the cost chargeable to

each burden center is a certain percentage of the general factory burden. Just what this percentage will be cannot be determined without taking into consideration the size of the center in question together with the size of the entire factory and the importance of the center in relation to the factory as a whole. General factory burden includes all executive expense, office expenses including office help such as clerks, storekeepers, draftsmen, etc.

Miscellaneous Charges—Miscellaneous charges include all burden charges not covered by the previous headings. These consist principally of liability insurance, fixed charges on inventory, etc. The actual amount is usually determined each month and distributed to the proper burden centers.

Having determined the proper number of burden centers necessary for a particular heat treating department and developed the burden charges for each center, the next step is the determination of a proper furnace-hour rate for each center based on the total estimated furnace hours that will be realized in a year for the particular burden center in question. This rate is determined by dividing the total burden charge developed for each center by the total estimated furnace hours for each center.

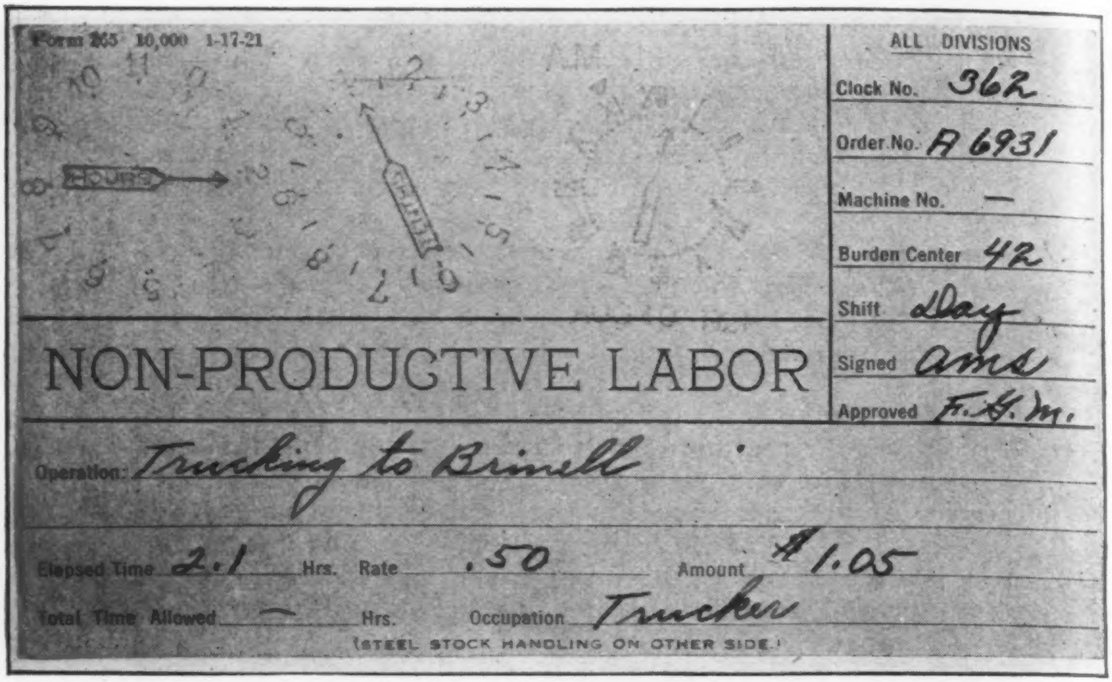
The accompanying table shows the development of a furnace hour rate for a burden center composed of six furnaces all of the same construction and size. The figures used are taken at random and merely show the detail analysis of how the furnace-hour rate is arrived at.

The determination of accurate costs can be brought about only by the use of an accurate system for the collection of all data that enters

Method of Determining a Furnace-Hour Rate

		Annual Amount
A—Land and Buildings Factor,		
1000 sq. ft. @ 30.00c per sq. ft.		$ 300.00
B—Equipment Factor,		
Furnaces (6)	$12,000.00	
Pyrometers	1,800.00	
Quench Tanks	400.00	
Monorail	200.00	
Hoist	600.00	
	$15,000.00	
Interest on $15,000 @ 5.0 per cent	$ 750.00	
Taxes on $15,000 @ .30 per cent	45.00	
Depreciation and Repairs on $15,000 @ 15 per cent	2,250.00	
	$3,045.00	
		3,045.00
C—Total Fixed Charges		$ 3,345.00
D—Indirect Labor		10,000.00
E—Supplies		1,500.00
F—Fuel oil (300,000 gal. @ 6c per gal.)		17,000.00
G—General Factory Burden (10.0 per cent)		3,500.00
H—Miscellaneous charges		655.00
I—Total Annual Burden		$36,000.00
J—Total estimated furnace hours—300 days per year, 20 hours per day, on six furnaces 300 x 20 x 6		36,000 hrs.

K—Furnace hour rate = $\frac{\$36{,}000.00}{36{,}000 \text{ hr.}}$ = $1.00 per furnace hour.



Form 265 10,000 1-17-21

ALL DIVISIONS

Clock No. 362

Order No. A 6931

Machine No. —

Burden Center 42

Shift Day

Signed ams

Approved F.H.M.

NON-PRODUCTIVE LABOR

Operation: Trucking to Brinell

Elapsed Time 2.1 Hrs. Rate .50 Amount $1.05

Total Time Allowed — Hrs. Occupation Trucker

(STEEL STOCK HANDLING ON OTHER SIDE.)

Fig. 2—Nonproductive labor ticket covering all labor not pertaining directly to the actual heat treating operation

into costs. This is secured by the use of a job ticket system with accurate time clocks for measuring the exact elapsed time of each operation in hours and tenths of an hour. In the heat treating department it is possible to collect all data by the use of three kinds of job tickets, productive labor, nonproductive labor and lost time tickets. A detail description of each job ticket is given below.

In heat treating parts where they are put through in heats, one ticket is made out for each man of the crew and for each individual heat. In case parts are treated in continuous furnaces or as a continuous operation such as loading one piece and pulling one piece, one ticket for each member of crew is satisfactory as long as operation progresses in the regular way. The sample ticket shown in Fig. 2 shows in detail how each ticket is filled out. The particular operation being performed and whether this operation is regular or extra is checked. This enables the time office to collect all data for payroll purposes and the cost department to charge the cost to the proper account number. The productive labor ticket is used on all operations that enter into the actual heat treating of the part in question.

The nonproductive labor ticket, shown in Fig. 2, is used for all labor that does not pertain to the actual heat treating operation such as janitor work, clerks on hourly rate, truckers, etc. Many times it is best to give piece rates on nonproductive operations such as steel stock handling, etc. In this case the cost data is entered on the back side of the ticket as indicated in Fig. 3.

All lost time is collected and charged against the proper account number. This is an important item in the heat treating department. The heat treating superintendent never realizes the amount of lost time that exists in his department until each individual case is brought to his atten-

tion so that he can see the dollars and cents actual loss. A lost time ticket is shown in Fig. 4.

On many heat treating operations run on the piece work system, times occur when unforeseen difficulty is encountered that prevents the crew from making an amount which is equal to what they would have made had they been working day rate. If the difficulty encountered was not due to any neglect on the part of the crew, it is only fair that an allowance be made for the same. It will be noted that provision is made on this ticket for the approval of the division superintendent. This is important. In our plant we even go a step further on these particular

STEEL STOCK HANDLING

PART NO.	NO. PCS.	WEIGHT NET TONS	RATE	AMOUNT
XM3029	70	2.3	.07	.16
21428	300	15.0	.07	1 05
A6991	50	2.5	.07	18
JE32	400	2.0	.07	14
KL162	350	7.7	.05	38
21689	360	11.5	.08	92
K2186	110	10.0	.07	70
XY71A	3000	50.0	.06	3 00
TOTAL AMOUNT				$6.53

Fig. 3—Frequently it is desirable to give piece rates on nonproductive operations such as steel stock handling and these are entered on the back of the nonproductive labor ticket as shown

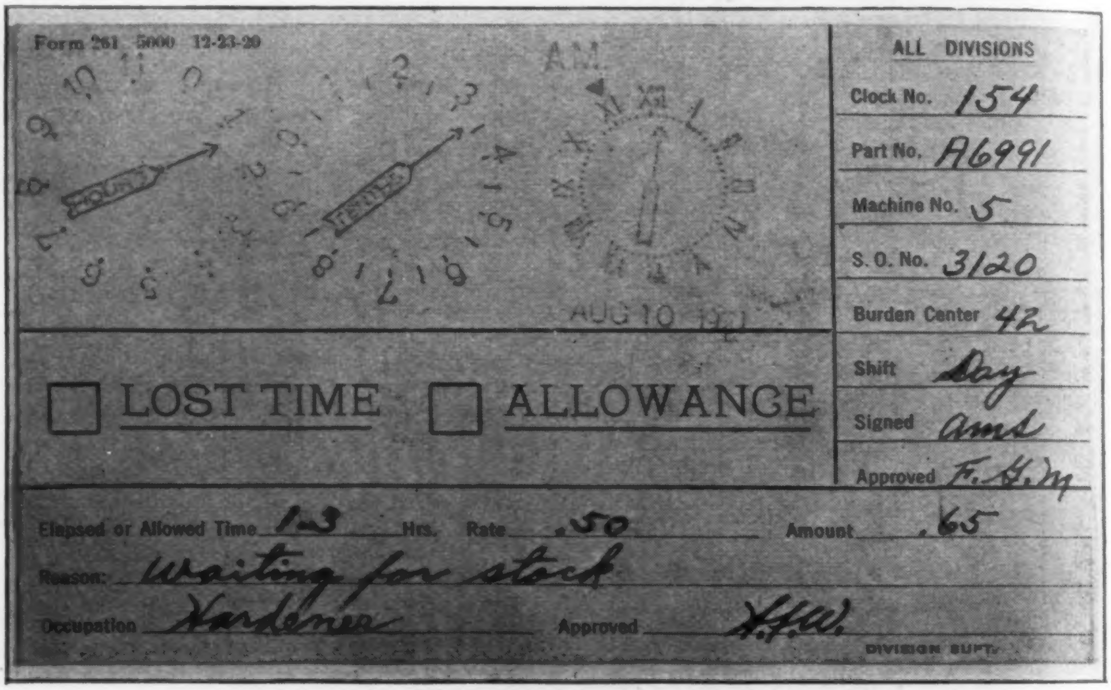
tickets and have them brought to the attention of the works manager before being urned over to the time office and cost department.

It is necessary in collecting cost data to make sure that every employe working either piece work or day work shall have a job ticket all the time. This makes it possible to divide the time accurately and see that same is charged properly by the cost department.

It will be noted that in the development of burden charges a large number of items are based on estimate. The cost as determined by using these burden charges, therefore, are not absolute costs. They are approximately accurate and for unit cost study in the plant, they are entirely satisfactory. However, for the preparation of actual profit and loss state-

ments for each month, it is necessary to go further. The balances remaining in the various burden accounts after credit has been entered for earned burden are transferred to the unearned burden and burden variance account at the close of each month. A debit balance will represent a loss due to unused heat treating capacity or an increase in the actual burden charges over the estimate or standard. Statements showing detail analysis of this account are prepared monthly.

It is impossible to overestimate the effect of proper cost analysis on the heat treating department. It has been general policy for years to keep costs away from the shop foreman and superintendents. The heat treating superintendent of today must be able to think in terms of dollars and cents. The only way he can be educated to do this is to secure from the cost department full information on the costs of each operation in his


Form 261 5000 12-23-20

ALL DIVISIONS
Clock No. 154
Part No. A6991
Machine No. 5
S. O. No. 3120
Burden Center 42
Shift Day
Signed ams
Approved F. G. M.

LOST TIME ALLOWANCE

Elapsed or Allowed Time 1.3 Hrs. Rate .50 Amount .65
Reason: Waiting for stock
Occupation Hardener Approved H. H. W.
DIVISION SUPT.

Fig. 4—Lost time and allowance ticket showing how lost time is charged against each account. This is an important item

department in statements issued by the cost department at least once per month. These statements should show the unit cost on each operation on each job run, detail analysis of all lost time showing dollars and cents actual loss and subdivided into causes, and a detail analysis of all extra operations performed placing definite responsibility for same.

A study of these monthly reports enables the heat treating superintendent to definitely locate where the losses occur so he can take immediate steps to reduce them to a minimum. A comparison of these statements with those for the month before will show at a glance actual progress made in reducing heat treating costs.

From these statements it is possible to prepare unit costs per piece or per pound on the different jobs and for each individual operation on a given job. All pieces rejected in the heat treating department should be taken to a definite location daily. The first thing each morning a conference should be held and each piece gone over carefully. At this con-

ference the dollars and cents actual loss to the company should be brought out and impressed upon the foremen as well as the men actually causing the rejection. If this study is carried out carefully on the part of every one concerned, the heat treating superintendent will find that his costs can be lowered materially and his production efficiency greatly increased.

MR. PORTER: I wanted to ask the speaker about the size of the plant in which he uses this system, the number of men involved and how easily the data is collected. I studied that thing in machine work. It was just the same principle. I found it extremely difficult to get that data together myself.

Discussion of Mr. Wood's Paper

MR. WOOD: In our shop when we are running normal, we have about 750 men working, and it is necessary to have two production clerks in the shop to gather the data. In addition to that we have two men in the cost department which prepare all the cards. The reason we are able to do that is because of the simplicity of the cards themselves.

One question that has already been raised, going into a detailed cost discussion is that each company always has its own particular cost method, which it has worked up through a number of years, and this company finds that this is particularly adapted to its particular work. We don't recommend that they change their cost system, but all we do want to do is to impress the importance of the different individual units, to make sure they are included. You would be surprised to find out how many companies neglect a lot of the important items. In the drop forge industry, it is even more pronounced than in the straight heat treating.

MR. PORTER: Do you use a tabulating machine?

MR. WOOD: We don't at the present time, although it is a simple matter to punch holes in the cards and use a sorting and tabulating machine.

CHAIRMAN HARTZELL: This is an extremely interesting topic. I believe that the report submitted by the Commission of Engineers, who investigated about three hundred steel farbicating plants in the country on the matter of time, material, and man waste, arrived at some such conclusions as these.

Only ten per cent of the three hundred plants in this country knew which it cost them to waste man power. About fifty per cent of the three hundred had no system whatsoever for determining cost. Thirty-five per cent did not make more than $5,000 profit. That was startling.

Yesterday I was talking with the representative of a consulting engineering firm along these lines, and he said that actually, while things were going so well, he thought his company was making money. Then when the slump came and he began studying his own company he found that they were not making money, but were actually losing money. That is to say, money was coming in so fast and it went out so fast they thought go into another concern and show that concern where they were losing they were making money when actually they were losing it, yet he could money. He said it was a startling revelation.

HEAT TREATMENT OF CHROME STEEL FOR BALL BEARINGS

By Haakon Styri

HIGHEST grade steel for ball bearings contains about 1.0 per cent carbon and 1.4 per cent chromium and, therefore, must be heat treated with the greatest care to give the best results, both during manufacturing and as the finished product.

Some of the material is delivered to the plants in a hot rolled condition, with a microstructure of lamellar pearlite and cementite boundaries when it is to be used for forgings of balls or ball races. A specimen of this is shown in Fig. 1. However, most material is delivered in the annealed condition for the automatic machines and must have a structure consisting of fine granular pearlite, as shown in Fig. 2. If the structure contains any lamellar pearlite the Brinell hardness generally will be higher and the cutting tools will be dulled quicker. Figs. 2, 3 and 4 show structures with Brinell hardness respectively 180, 203 and 236. Occasionally we find annealed bars which are hard in spots where the temperature has been too high during annealing and has caused more or less lamellar pearlite to be formed, as shown in Fig. 5. Such material, as well as material with seams, Fig. 6, and carbide segregations and slags, Fig. 7, is rejected.

Before the material is subjected to hardening it must have a structure of granular pearlite. All forged material is therefore annealed before hardening. A careful hardening is of the greatest importance for the quality of the product, and it is first of all necessary that the steel be in homogeneous condition when it is ready to be quenched from the proper temperature. It is not enough that the steel has reached such temperature, but sufficient soaking must be allowed, in particular for chromium steels, which react slower than carbon steels.

Some experiments the author made on carbon steels some years ago will illustrate the effect of insufficient soaking. Carbon steels of 0.30, 0.50 and 0.80 per cent carbon content were heated rapidly in a hot furnace to just over the critical temperature and left only 5 minutes before they were cooled off slowly. Figs. 8 and 9 show that the transformation into pearlite or sorbite has started only in points, and parts of the material are retained as ferrite or divorced pearlite as in the original condition. If the material is quenched after such short time of heating, as shown in Figs. 10, 11 and 12, we find similarly that only a part has gone into solid solution and forms martensite, which often is not homogeneous as shown by Fig. 11. We get a similar condition in chrome steels when the temperature is too low or the time for soaking is insufficient as shown in Fig. 13.

When the steel has not been in the proper condition before hardening we can get martensite with streaks of cementite, Fig. 15, or with cementite boundaries, Fig. 14. Properly heat-treated steel will show fine martensite with granular cementite, Fig. 16. Overheating gives coarse martensite, Fig. 17 and, if exaggerated, even some austenite, Fig. 18.

Several interesting abnormalities have been found in hardening, which will be described later, as it may be of value first briefly to consider hard-

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A paper presented by title at the Indianapolis Convention. The author, Haakon Styri, is chief of the SKF research laboratory, SKF Industries, Philadelphia.

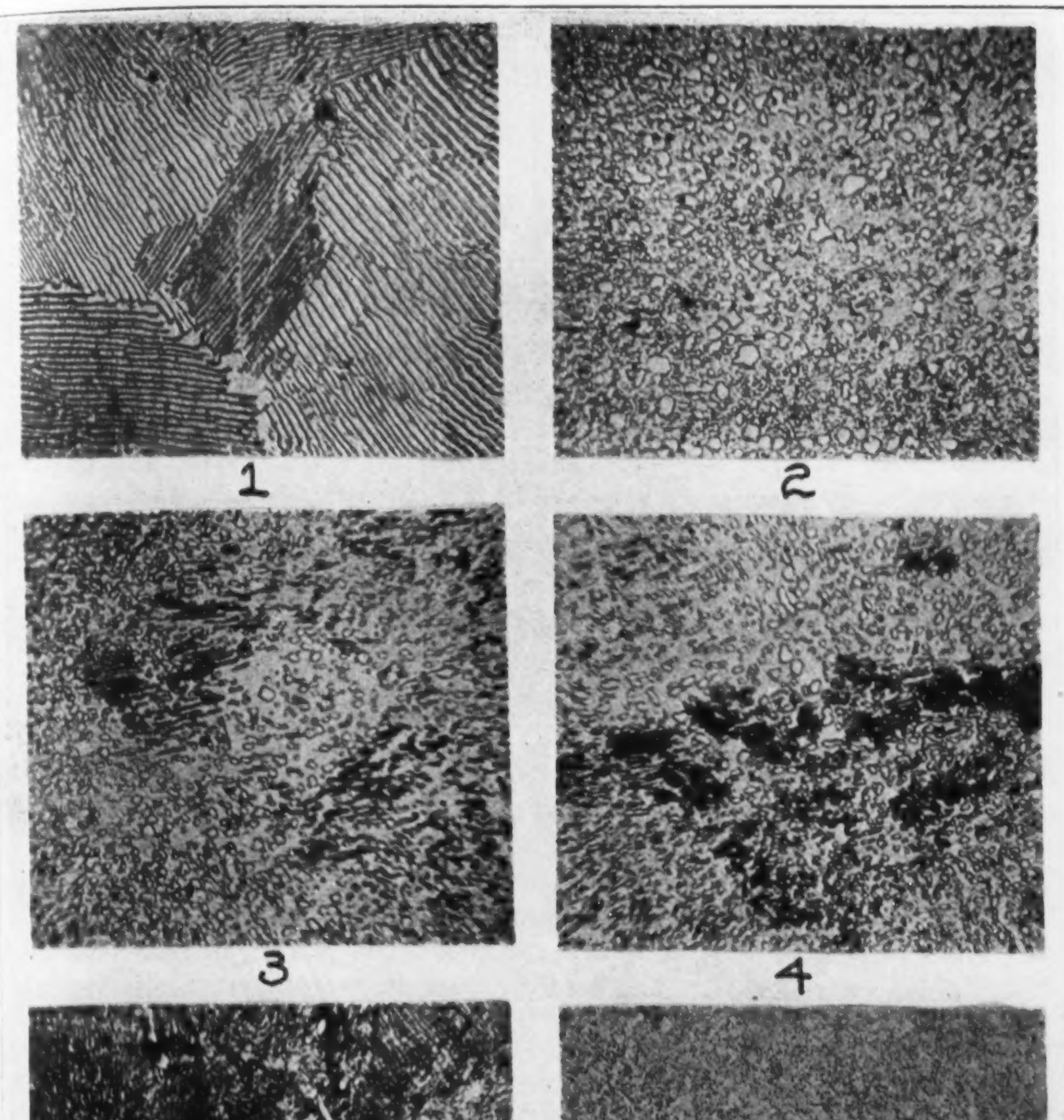


Fig. 1—Lamellar pearlite. Brinell 217. X 1000. Fig. 2—Granular pearlite. Brinell 180. X 1000. Fig. 3—Granular pearlite with a little lamellar pearlite. Brinell 203. X 1000. Fig. 4—Granular pearlite with considerable sorbitic pearlite. Brinell 236. X 1000. Fig. 5—Sorbitic and lamellar pearlite with cementite boundaries. Brinell 305. X 1000. Fig. 6—Surface seam from hot rolled bar stock, not rough turned. X 1000

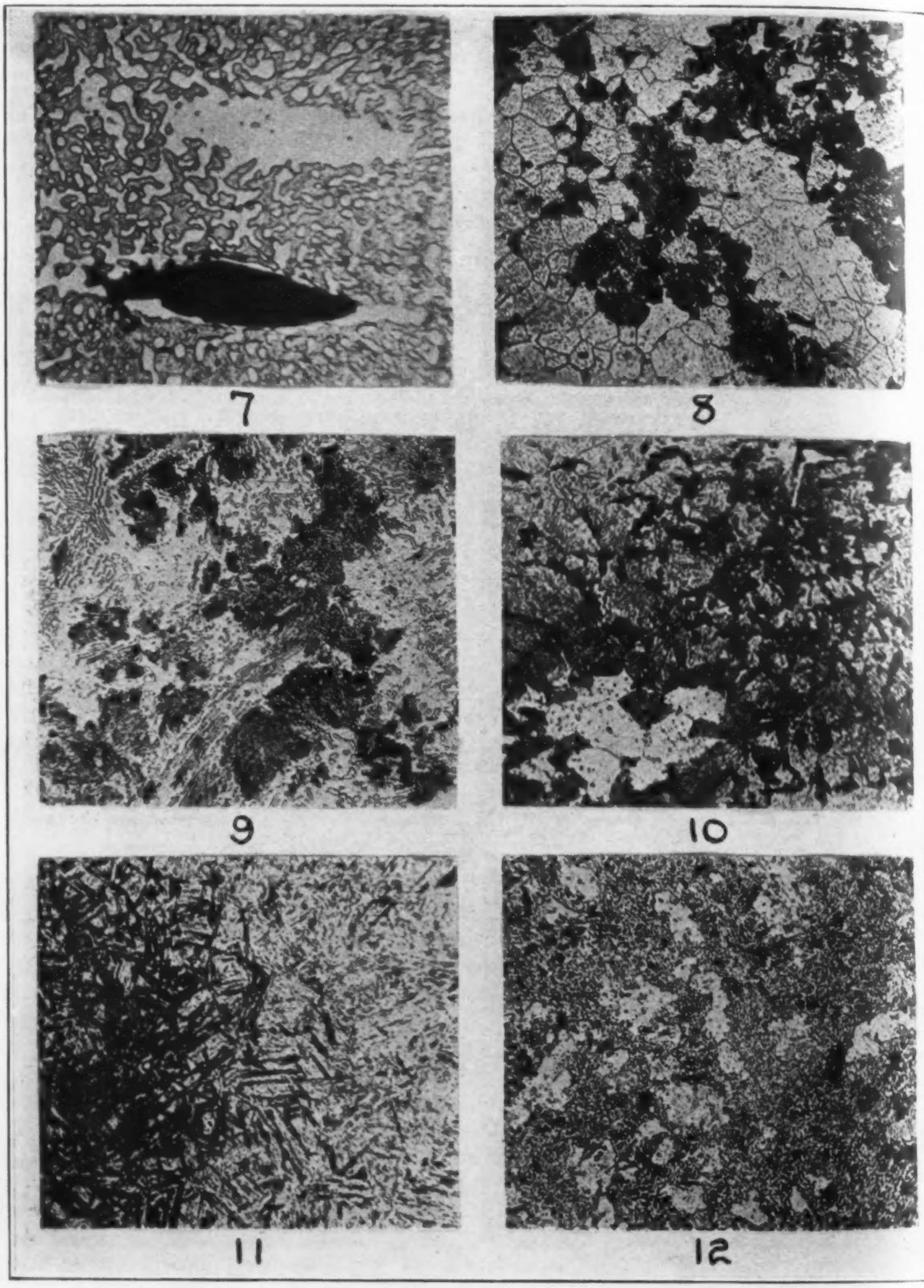


Fig. 7—Martensitic structure with carbide and slag. X 1000. Fig. 8—Steel of 0.30 per cent carbon heated to 720 degrees Cent. for 5 minutes and furnace cooled. X 250. Fig. 9—Steel of 0.50 per cent carbon heated to 720 degrees Cent. for 5 minutes and furnace cooled. X 250. Fig. 10—Steel of 0.30 per cent carbon quenched in water from 720 degrees Cent. X 250. Fig. 11—Steel of 0.30 per cent carbon quenched in water from 900 degrees Cent. X 250. Fig. 12—Steel of 0.80 per cent carbon quenched in water from 720 degrees Cent. X 250

ening in general. It is not the intention to elaborate on this, as the author two years ago gave a paper on this subject before the Pittsburgh Chapter of this Society, in which he tried to give an outline of the most important facts known about hardening of steel, and which would form a satisfactory basis for a clear theory of hardening. It may be sufficient only to mention the most important of these facts, namely, the simultaneous contraction, heat absorption and loss in magnetism on heating through the critical range and the reverse process at slightly lower temperature on slow cooling. When steel cooled rapidly, such changes do not occur at the same temperatures, but take place more or less marked at lower temperatures, as it is very clearly shown in the recent investigation of Portevin & Garvin[1].

On investigating the influence of rate of cooling on the hardening of carbon steels, they established without doubt that the formation of troostite occurs through a temperature range above 600 degrees Cent. with evolution of heat and is prevented only by sufficiently rapid cooling through that range, or critical rate of quenching. They also showed that if the cooling is rapid enough to prevent the formation of troostite with its corresponding heat evolution, another heat evolution may take place below 350 degrees Cent. and the structure of steel showing this phenomenon will be martensitic. The transformation of solid solution into martensite, in other words, has taken place below 350 degrees Cent. This transformation is slow relative to the rapid troostite formation at the higher temperatures. With an accelerated rate of cooling the troostite formation gradually gets weaker until, at the critical rate of quenching, it disappears and the martensite transformation only takes place. Both troostite and martensite can be found in the same specimens with quenching rate near this critical rate, and are found simultaneously even in special steels which have much lower critical rate of quenching.

The critical rate of quenching under otherwise similar conditions is least near the eutectoid composition—which means that when the steel has more carbon or less carbon than 0.9 per cent, it is necessary to have more rapid cooling in order to prevent troostite formation. If cooled more rapidly through the range above 600 degrees Cent., but with cooling interrupted at lower temperature, troostite can be formed at the lower temperature of 400 to 450 degrees Cent.

The initial state of the steel is of considerable importance, as shown by the effect of increase in quenching temperature. This is shown by Portevin but can, to a large extent, be explained by cooling curves calculated by K. Heindlhofer of the S. K. F. laboratory. His calculations were undertaken in order to get a general idea of the cooling of different points in a sample under given conditions. These were assumed to be as follows:

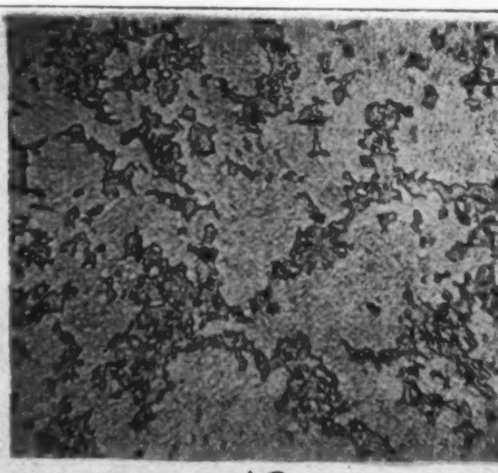
Steel ball of given dimension, 1 centimeter radius.

Heat conductivity of steel, 1 gram calorie per centimeter per second.

Specific heat of steel, 0.114.

The cooling was supposed to take place in a liquid which was constantly renewed so that it kept its temperature constant, and there was supposed to be no contact resistance between the ball and liquid. Cooling curves, temperature and time were calculated for points at equal inter-

1. Portevin and Garvin Journal Iron and Steel Institute, 1919.



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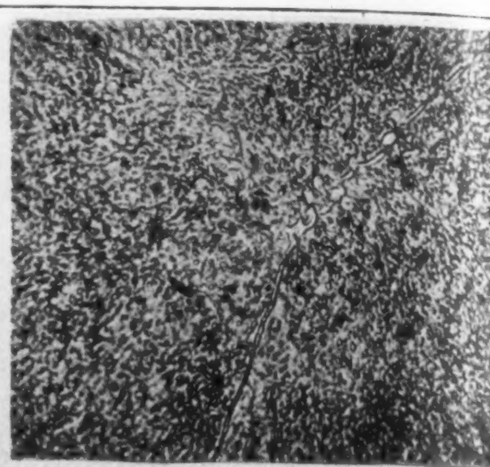

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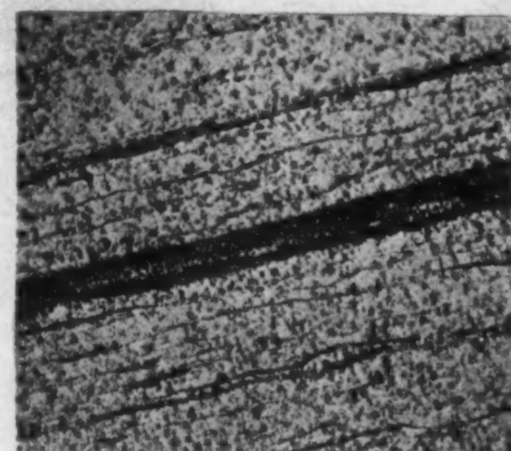

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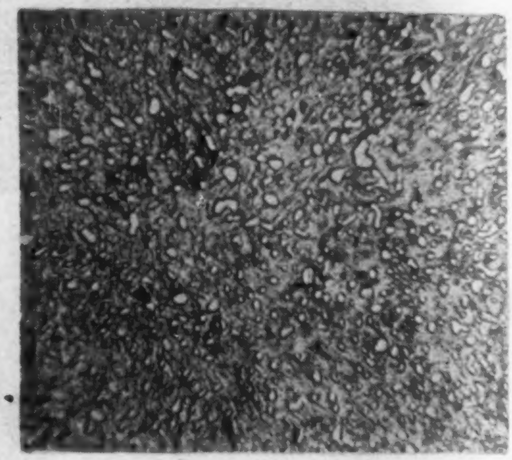

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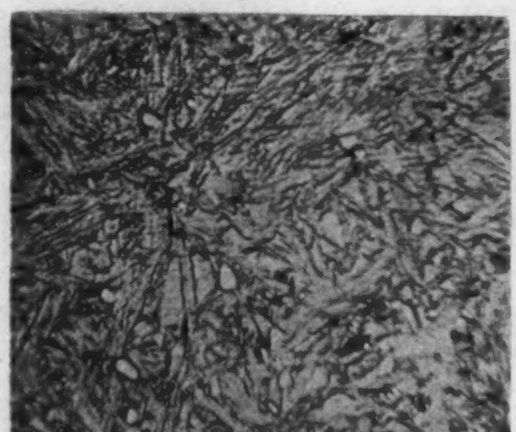

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Fig. 13—Undissolved granular pearlite in martensite lightly etched. X 500. Fig. 14—Martensitic structure with network of interrupted cementite boundries. X 1000. Fig. 15—Very streaky structure showing cementite streakiness. X 50. Fig. 16—Good hardened structure in ball bearing steel. X 1000. Fig. 17—Very coarse martensitic structure due to overheating. X 1000. Fig. 18—Ball bearing steel quenched from 1900 degrees Fahr. in oil and drawn to 400 degrees Fahr. showing coarse martensite in an austenitic ground mass. X 500.

vals of 1/10 of the radius. The result of the calculation may be summarized as shown in Fig. 19.

The temperature ordinate at zero time represents the initial temperature difference between the ball and the liquid, and can be expressed in per cent, representing any initial temperature chosen. For any temperature we can therefore use the percentage scale and the cooling curves will have the same form. For a variation in diameter of the ball there is a simple

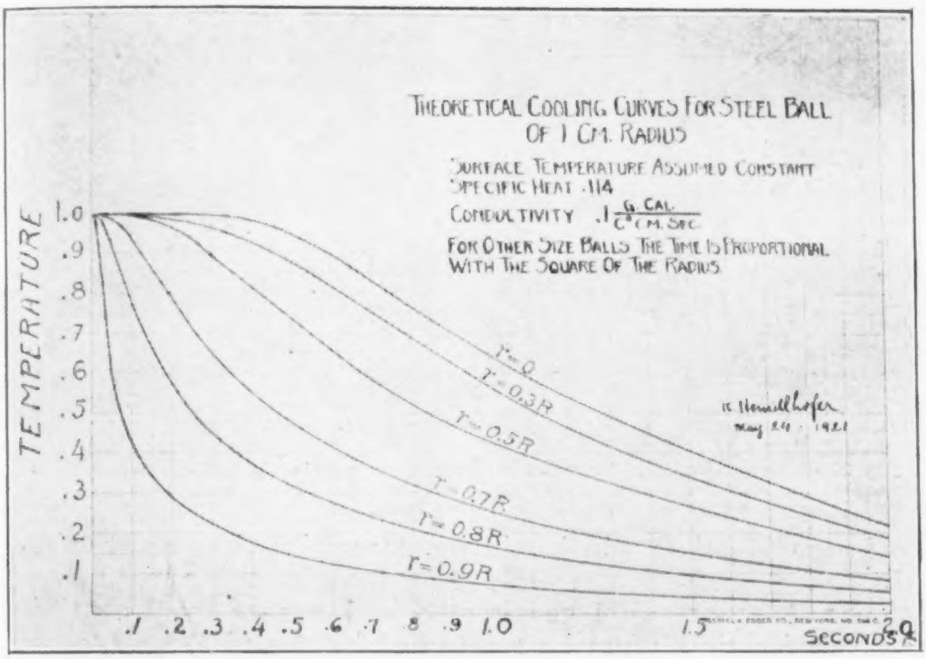


Fig. 19—Theoretical cooling curves for steel ball 1 centimeter in radius. By Heindlhofer

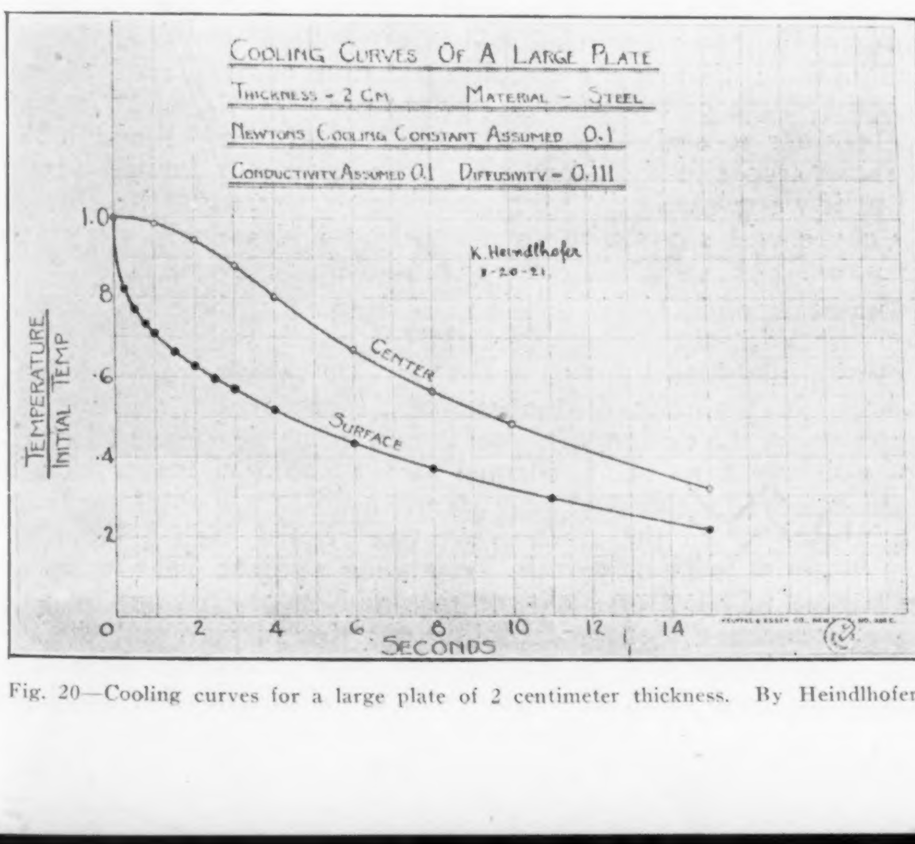


Fig. 20—Cooling curves for a large plate of 2 centimeter thickness. By Heindlhofer

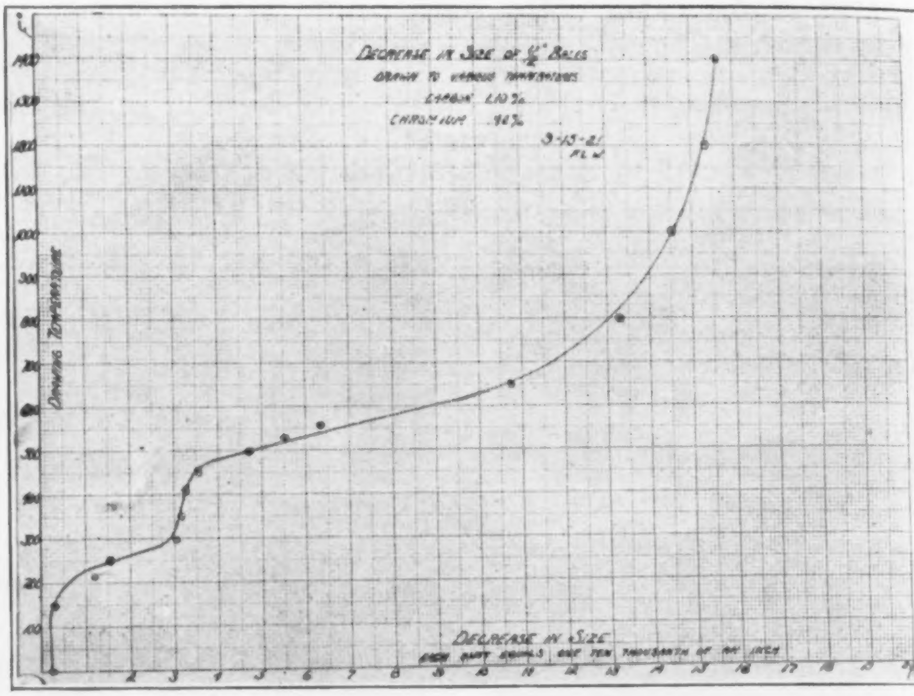


Fig. 21—Change in size of balls due to drawing to different temperatures. By Wright

relation in cooling time which will increase with the square of the diameter. In other words, if the scale used for dimensions is changed from, for instance, 1 square = 1 centimeter to 1 square = 2 centimeters the figures given for time must be multiplied by 4 and the same curves can be used.

The whole system is readily understood when made up in a wooden model. To illustrate the use of such a model let us see what happens in the different points when the ball is quenched from 750 degrees Cent. and we assume that for a given steel the critical rate of quenching through the range of troostite formation, near 600 degrees Cent., is about 100 degrees per second. Where the temperature drop through this range is less rapid, troostite should result. This can occur for the center of the ball. But if we raise the initial quenching temperature, the corresponding cooling curve will show a more rapid drop and we will get no troostite at this point.

If the heat conductivity in the steel decreases, the corresponding time will increase with the 2nd power. If the cooling liquid is changed, the result can be imagined by stating that for a given liquid the layer next to the ball will be maintained at a constant temperature, and we can again use our curve representing the total temperature in percentage. But if a layer of a different nature is formed at the contact surface, for instance, a layer of steam is formed when water is used as a quenching medium, or if scale is present on the surface, we can regard such a layer as an insulating material with a certain resistance against heat transfer. The cooling curves will fall at a slower rate and there will not be so great a difference between the rate of cooling for the surface and the center of the ball. The better the insulation, the less difference there will be in the rate of cooling. Mr. Heindlhofer has calculated the cooling curves

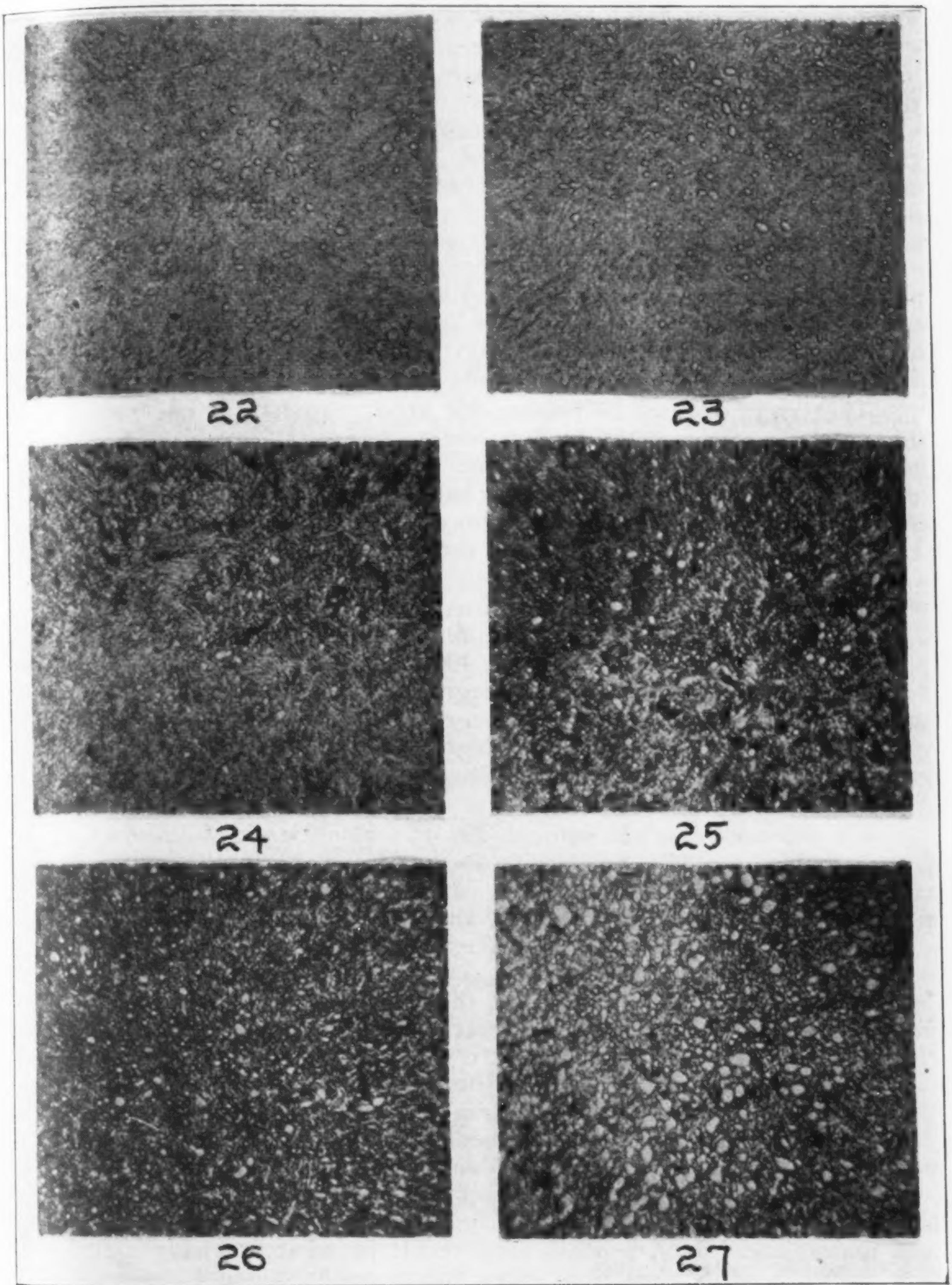


Fig. 22—Ball of ½-inch diameter, hardened but not drawn. X 1000. Fig. 23—Ball of ½-inch diameter, hardened and drawn 30 minutes at 255 degrees Fahr. X 1000. Fig. 24—Ball of ½-inch diameter, hardened and drawn 30 minutes at 450 degrees Fahr. X 1000. Fig. 25—Ball of ½-inch diameter, hardened and drawn 30 minutes at 500 degrees Fahr. X 1000. Fig. 26—Ball of ½-inch diameter, hardened and drawn 30 minutes at 675 degrees Fahr. X 1000. Fig. 27—Ball of ½-inch diameter, hardened and drawn 30 minutes at 924 degrees Fahr. X 1000

for the surface and the center of a big plate under the assumption of a surface insulation as indicated in Fig. 20.

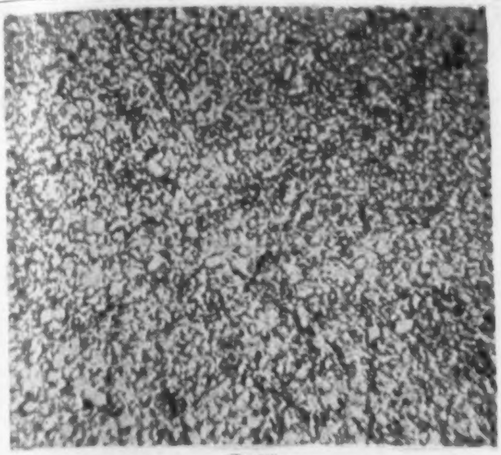
However, it is not only an increase of initial temperature shown that may account for a change in structure. The higher temperature to which the steel has been heated may have caused a structural change so that only a slower rate of cooling is necessary in order to suppress the troostite formation. The investigation of Andrew Rippon Mills[2] throws light on this question. The excellent curves given for the expansion on heating of steels of different carbon contents show, in addition to the known contraction on changing from alpha to gamma iron, that there is an expansion of gamma due to solution of cementite. This expansion is not completed at Acm when cementite has disappeared in the microstructure, but continues until considerably higher temperature is reached. They seem to attribute the known increase in volume of a hardened steel over the annealed to this cementite expansion.

The larger volume of martensitic steels can hardly be explained by this only. It seems to the author that part of such expansion at least can be accounted for by minute slippage in grains when gamma changes to alpha iron. Some experiments on change of dimension by drawing hardened balls which we have made, may be of interest in this connection. These measurements are shown in the curves in Fig. 21.

Undoubtedly there is a decrease in volume when a hardened specimen is drawn to higher temperatures, and this is accompanied by some separation of cementite from solution and a coagulation which, as the pictures show, is very evident at 400 degrees Cent. Fig. 22 was not drawn; Fig. 23 was drawn at 120 degrees Cent.; 24 was drawn at 230 degrees Cent.; 25 was drawn at 260 degrees Cent.; 26 was drawn at 355 degrees Cent.; 27 was drawn at 495 degrees Cent.; 28 was drawn at 650 degrees Cent. However, the contraction seems to continue after the cementite is separated out.

We will now describe some of the abnormalities in the quenching referred to above. The martensite formation is, as mentioned, found to take place below 350 degrees Cent. If the rate of cooling is fast enough this may be depressed and we get austenite. The formation of martensite, however, is not sudden. It takes time to complete it. Therefore, it may well happen that a change can occur, when for some reason the cooling is interrupted. At such time there will be a gradual fall in temperature from the center to the surface of the specimen. Let us imagine that we cool off a ball rapidly until the surface temperature has fallen below the temperature for martensite formation, 350 degrees Cent., and that the cooling be interrupted for a moment by a local steam pocket. The heat from the interior will then raise the temperature of the spot when some martensite has formed and draw this back to troostite. At this time the steam pocket may disappear and the normal rate of cooling be resumed so that the originally unchanged solid solution will change into martensite. Such process may result in what we have called surface troostite, which we have often found on hardened balls, as shown in Fig. 29. We have found similar formations in a block of straight carbon steel quenched according to the hump method. Near the surface a decarbonized layer is found, then a layer of surface troostite, as shown in Fig. 30, then one of martensite, as shown in Fig. 31, then one of ordinary

2. Andrew Rippon Mills, Journal Iron and Steel Institute, 1920.



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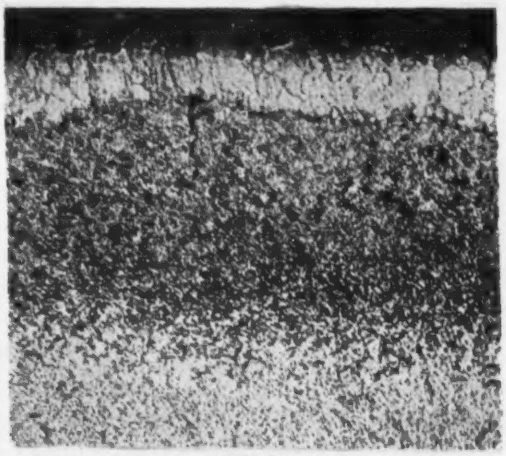

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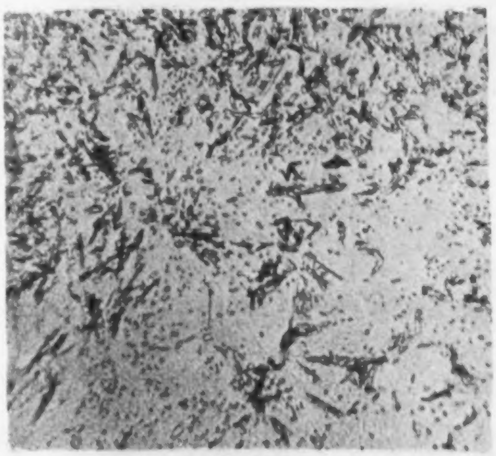

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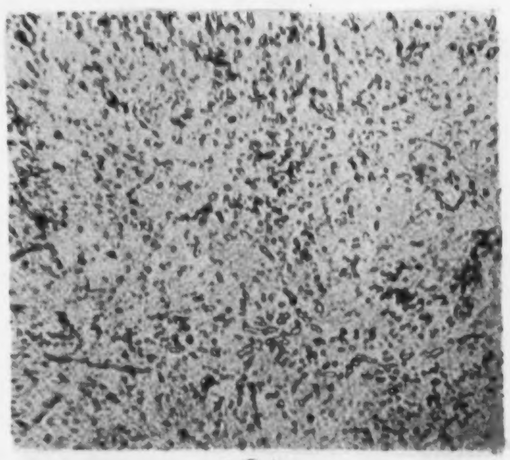

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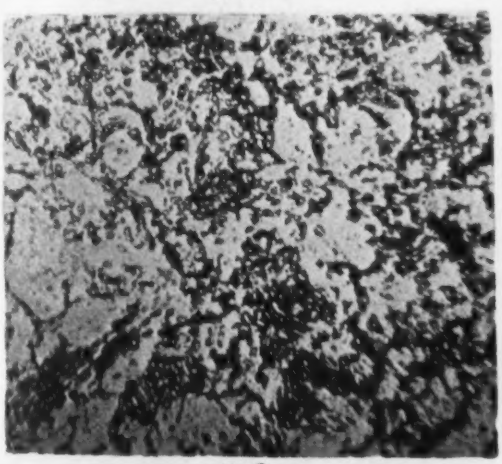

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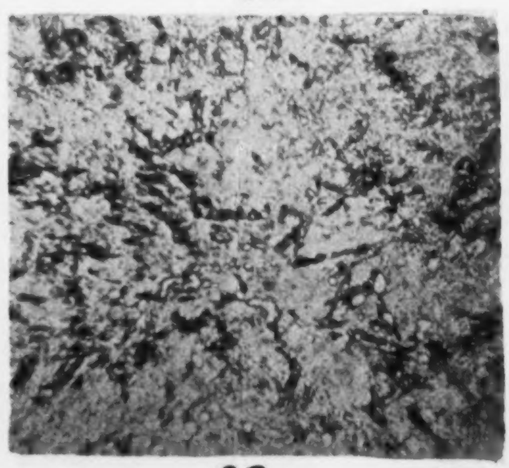

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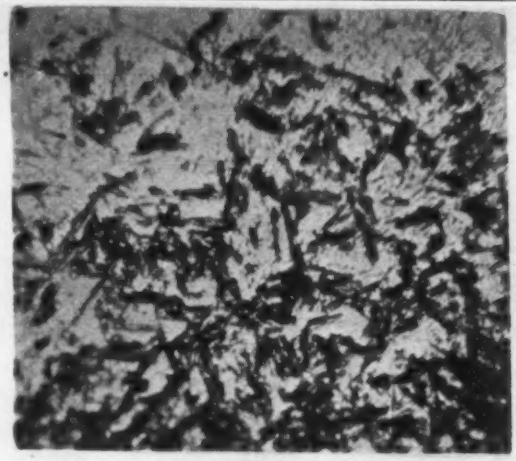
Fig. 28—Ball of ½-inch diameter, hardened and drawn 30 minutes at 1200 degrees Fahr. X 1000. Fig. 29—Surface troostite with some decarbonization. Hump method used. X 100. Fig. 30—Straight carbon tool steel hardened by hump method, showing surface troostite. X 500. Fig. 31—Specimen showing martensite beneath surface troostite. X 500. Fig. 32—Same as Fig. 30, showing troostite beneath the ⅛-inch layer of martensite. X 500. Fig. 33—Surface troostite in martensite. X 1000



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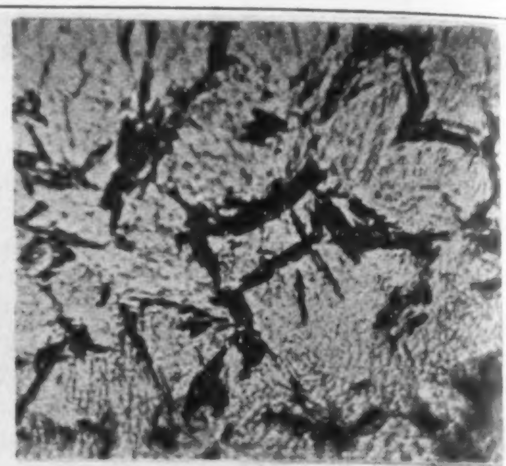

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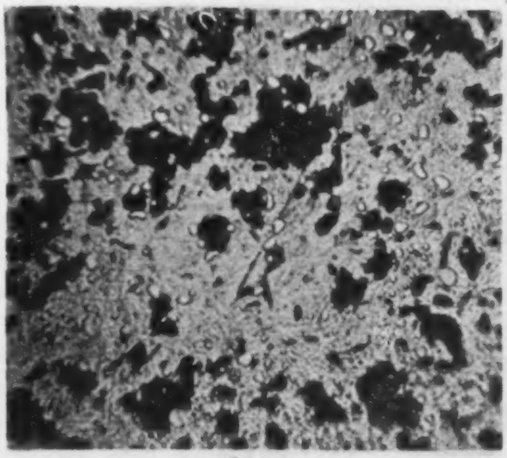

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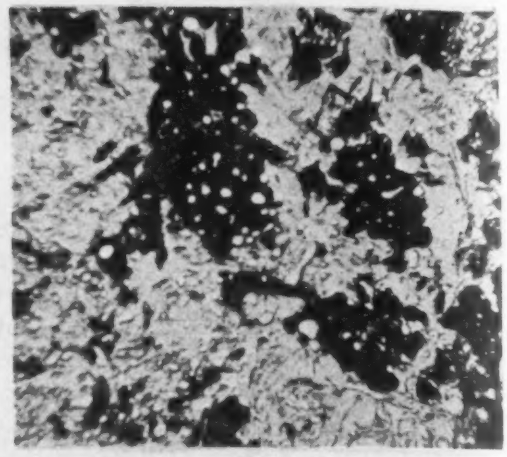

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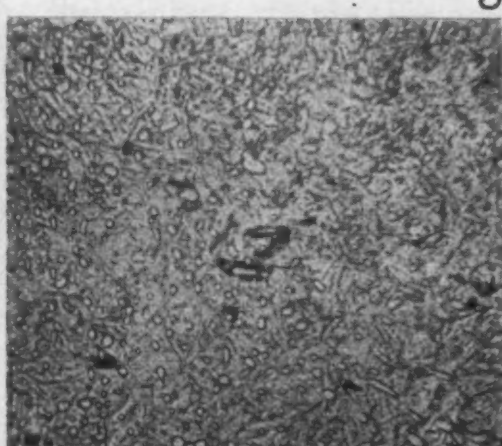

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Fig. 34—Surface troostite with some decarbonization. X 1000. Fig. 35—Surface troostite in martensite. X 1000. Fig. 36—Surface troostite in martensite. X 1000. Fig. 37—Surface troostite in martensite. X 1000. Fig. 38—Secondary ferrite in martensite. X 1000

quenching troostite, as shown in Fig. 32. It is well to notice here that such troostite mixed with martensite is produced in quenching and not in drawing. The drawing troostite is homogeneous throughout, as shown in Figs. 24 and 25.

The surface troostite generally has a form entirely different from troostite formed in steel by slow cooling through the range around 600 degrees Cent. Figs. 33, 34 and 35 show forms of troostite found on steel balls in the shape of needles more or less drawn, but there are forms, shown in Figs. 36 and 37, also from surfaces which are much like troostite formed in the interior when too slowly cooled through the critical range. Mr. Hultgren, of Sweden, has in particular called attention to these various forms of troostite. A further abnormality is what Mr. Hultgren has called secondary ferrite, as shown in Fig. 38, on which he has thrown some light in his investigation of tungsten steels where he shows the formation to start on retarded cooling in the temperature range between 600 to 525 degrees Cent. and to be maximum around 500 degrees Cent.

In conclusion the author wants to emphasize the necessity of thorough soaking at temperature before quenching and a regulation of the quenching temperature to correspond to size of specimen and system of quenching. He also wants to point out the importance of recognizing the different forms of troostite, in particular the difference between troostite formed during the quenching period and troostite formed by the drawing of martensite. The latter troostite is homogeneous, the former is found in conjunction with martensite, or sorbite, and is not entirely homogeneous when it happens to occur alone.

Discussion of Mr. Styri's Paper

CHAIRMAN HARDER: Have you observed in any case an increase in volume instead of a decrease in any of the drawing operations?

MR. STYRI: Yes, we have, but not for this kind of steel. For another type of steel we have found an increase in volume at about 450 degrees Fahr. For that kind of steel we had the curve coming up this way. That is to say, first a decrease in size, and then an increase in size, for a higher drawing temperature. That can be explained only by the transformation of gamma iron. It is an increase in volume from austenite to martensite. This question belongs to another investigation and it would take considerable time to go into that.

CHAIRMAN HARDER: Would you consider it possible that the decrease in volume in the second part of that curve might be due to the decrease in volume of a precipitated cementite, due to the growth of cementite particles during the drawing operation?

MR. STYRI: I don't think so because a single coagulation of cementite should not cause a decrease in volume. On the other hand, we know that cold worked steel has a larger volume than unworked and will contract on being drawn to higher temperatures due to closing up of slips.

Comment and Discussion

Papers and Articles Presented Before the Society and Published in Transactions Are Open to Comment and Criticism in This Column—Members Submitting Discussions Are Requested to Give Their Names and Addresses

HIGH SPEED STEEL PAPER IS CORRECTED

THROUGH an unfortunate set of circumstances, three errors appeared in the paper "Physical Tests on High Speed Steels," by A. H. d'Arcambal, which appeared on page 586 of the April issue of TRANSACTIONS. To clear up any question which may have been caused by these inaccuracies, the corrections are given below.

In the sentence, "Drawing to 1100 degrees Fahr. into oil or lead," etc., which begins in the ninth line on page 591, a number of words which appeared in the author's manuscript were dropped out with the result that the sentence is meaningless. With the missing words supplied, the sentence should read "Drawing to 1100 degrees Fahr. produced a small amount of troostite with its corresponding softness. Specimens of both types of steel quenched from 2350 degrees Fahr. into oil or lead and not drawn possessed the polyhedral structure of austenite with only a few undissolved carbides and tungstides."

In the small insert at the bottom of page 591, the chromium content should have been shown as 3.31 per cent instead of 3.13 per cent as was printed. On page 593 in the eighteenth line from the top of the page, Figs. 25-30 should have been referred to instead of Figs. 18-24.

Mr. d'Arcambal also calls attention to the fact that on page 567, the fifteenth line should have referred to a 14.0 per cent chromium steel instead of a 0.40 per cent chromium steel as shown.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

QUESTION NO. 5. *What is needle bar stock?*

QUESTION NO. 6. *Does the temperature in the carbonizing box or pot at any time become greater than that of the furnace in which it is being heated?*

QUESTION NO. 7. *May tools be heat treated properly in a furnace in which copper is present?*

QUESTION NO. 8. *What is the effect of high and low silicon in tool steel?*

QUESTION NO. 9. *In carbonizing does not the carbon increase slightly even in the core section?*

QUESTION NO. 10. *What surface of steel, that is, machined, cold rolled, hot rolled or cold drawn, carbonizes fastest and why?*

QUESTION NO. 11. *Has high speed steel ever been carbonized and if so what were the results?*

QUESTION NO. 12. *How and why is cast iron heat treated? Is there such a process as ageing or seasoning castings other than by annealing?*

QUESTION NO. 13. *A swaging die for tubing receives 3600 blows per minute. It has been found that a scleroscope hardness of about 95 is necessary to prevent excessive wear. When this hardness is obtained considerable trouble is encountered in warping during heat treatment. Is there any steel in which this hardness can be procured without warpage?*

QUESTION NO. 14. *What can be done to prevent coiled strip stock from sticking together when annealed? This stock is bright rolled, wound into coils and pack annealed and the coils sometimes stick together. It cannot be softened by heating below the critical range for fear of grain growth due to critical straining.*

QUESTION NO. 20. *What are the causes of warping in the heating and cooling of steel?*

ANSWER. By Stanley A. Richardson, instructor in metallurgy, Lewis Institute, Chicago.

The warping of steel has been a problem to steel treaters, it may be said, since steel treating began. With the increasing use of heat treated structural parts, particularly those of considerable length or cross section, the problem has increased in importance. It is held quite generally among shopmen that warping is in some way the result of nonuniform heating or cooling. Cracking, during or subsequent to heat treating, is thought to be due largely to the same thing. That is to say, warping and cracking are phenomena of like kind, differing only in degree. It is probably correct to say that the majority of technical men attribute these phenomena to the volume changes associated with the passage of a piece of steel through critical temperatures.

It is evident that the aforementioned views are not antagonistic, but are substantially in agreement. If a volume change causes a piece of steel to warp or crack, it must be because there is an interval between the time of the change in various parts of the piece, and this of course means that the rate of cooling, or heating, is not uniform. It is undoubtedly true, however, that there are many heat treaters who overlook the fact that a piece of steel undergoes a sudden expansion while cooling through the critical temperature, or, the reverse on heating.

In addition to the above, it is sometimes held that warping is due to a mechanical action, wherein the section of the steel cooled at the more rapid rate "upsets" the section cooling, at the slower rate. In view of the fact that in a piece of steel, one side of which is quenched in water, the quenched side is found to be longer than the side cooling in air, it is not clear to the writer just how this "upsetting" can take place. It is conceivable, and a matter of fairly common observation that steel can be warped by uneven heating before reaching the critical temperature. Such a condition is due, evidently, to the fact that because of differences in the rate of expansion of adjoining sections, stresses are set up which exceed the elastic limit of the steel and thereby produce distortion. Assuming homogeneous material, proper furnace design and proper furnace loading, should greatly reduce, if not eliminate this condition. Warping of this nature is probably more noticeable in the case of pieces of great length or uneven cross section. The tendency of steel to warp or crack under this condition is said to vary inversely with its thermal conductivity and directly with its coefficient of expansion. It is more pronounced, of course, in some steels than in others, probably reaching a maximum in high manganese steel, which can be cracked very easily by uneven heating.

The writer has listened to much discussion by practical men at recent meetings of the Chicago Chapter relative to the foregoing. However, after examining a number of the specimens presented, he is of the opinion that the real mechanism of warping in steels quenched from above the critical range, in the vast majority of instances at least, hinges upon the formation in the steel of varying amounts of the constituents marking the transition from austenite to pearlite, for example, martensite, troostite, and sorbite.

It is a matter of common knowledge among metallurgists that each of the metallographic constituents of steel possesses a different specific volume or density. Quantitative determinations confirming this have been made by various authorities, notably Maurer and other prominent European metallurgists and physicists. Martensite, the constituent produced by quenching a piece of properly heated steel in water, has a greater specific volume than any of the other constituents. In a piece of steel, the greater dimension of which is length, this is equal to saying that the piece will be longer after

quenching than before. Troostite and sorbite each have a specific volume somewhat less than that of martensite. When martensite and troostite, or troosto-sorbite are formed in quantity in a piece of steel, the ideal condition for distortion exists. The effect increases with increase in the carbon content, which means of course that the effect depends upon the total amount of martensite and troosto-sorbite present. A piece of low carbon steel containing these constituents will undergo a slight deformation, whereas in a high carbon steel the deformation will be quite pronounced, or, in most cases due to its low ductility, the steel will crack. The cracks are usually parallel to, and close to the line dividing the martensite from the troostite, and appear to be due to the tension placed on the martensitic area by the contraction accompanying the formation of troostite. Frequently in a high carbon steel, cracks appear also in the martensitic area in a direction at right angles to the previously mentioned dividing line. The tendency to crack is influenced profoundly of course, by the degree of temperature to which the steel is heated above the critical point, being greater in steel highly overheated. That is to say, coarse grained martensite is more brittle than that of normal grain size. The production of concentrated areas of martensite and troostite in a piece of steel may be caused by uneven quenching or cooling of the piece, unequal temperature throughout at time of quenching, unequal drawing or tempering, and probably, nonuniform distribution, or concentration of the elements, particularly carbon. The last mentioned condition can usually be corrected by a thorough anneal, while the others depend upon factors peculiar to any individual plant.

The following simple experiments, performed in studying this problem, are interesting, and can be duplicated in any shop. They were carried out under shop conditions without attempt to exact quantitative data. The changes in dimension were measured chiefly by tracing the outlines of the pieces on paper before and after the heat treating operations. Pieces of 0.20 per cent carbon, 0.50 per cent carbon, and 0.90 per cent carbon steel, each about 6 by 3 by 3/8 inches were heated to their respective proper quenching temperature and quenched about one-half of their width, that is about 1 1/2 inches in cold water, and the microconstituents noted. In addition, pieces of 0.50 per cent and 0.90 per cent carbon steel were heated and quenched uniformly, and then immersed for about one-half their width in cold running water and a drawing temperature applied to the upper edges with an acetylene torch. This temperature probably reached 900 degrees Fahr. at the upper edge of the pieces and graduated downward to the surface of the water. The results obtained including the cracking were almost identical with those obtained by quenching but one-half of the specimens in water and not tempering.

In the case of 0.20 per cent carbon steel it is necessary to quench the piece at least twice in exactly the same manner to produce a very marked deformation. This is to be expected when it is considered that steel of this carbon content can possess but 24 per cent of saturated martensite. As the stresses set up by each quenching exceed the elastic limit of the steel, the effect, that is the distortion, is cumulative. If the piece is very wide a bulge will be noticed on the ends of the section farthest from the surface of the water, for example, the section cooling at the slowest rate. This bulge will have a greater length than the troosto-sorbitic area, but less than the quenched or martensitic area. Upon examination it will be found to consist of lamellar pearlite.

The foregoing observations and experiments are not offered as being conclusive. It is believed, however, that they point toward an answer to a practical question—which answer the writer, at least has never seen or heard discussed. It would appear, then, that a very large part of the warping and cracking of quenched steels, while possibly due to uneven temperature conditions, is not due necessarily to unequal thermal expansion or contraction, but to the formation in the steel of transition constituents having different specific volumes.

QUESTION NO. 23. Why is it that a piece of hot rolled steel, of a given composition, will not harden in oil after carbonizing to the degree that a piece of the same composition will if first subjected to forging?

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Heat Treaters

By H. E. Gladhill

EFFECT OF COLD DRAWING

TENSILE STRENGTH INCREASE BY COLD DRAWING. By E. J. Janitzky, *Iron Age*, Vol. 109, Page 707.

Considerable data has been published on the influence of cold drawing on tensile strength, but no mathematical analysis has been made of it. On 0.10 per cent carbon steels the increase in tensile strength is equal to one thousand times the per cent reduction of area up to reductions of ninety per cent. Beyond this point several breaks are encountered in the curve. Beyond the breaks the increase is proportional to one-half the reduction of area. For higher carbon steels the breaks in the tensile strength curves come earlier. Neither previous heat treatment nor initial size affect the rate of increase in tensile strength.

HIGH SPEED STEEL

NOTES ON THE MANUFACTURE OF HIGH SPEED AND TUNGSTEN STEELS. By J. W. Weitzenkorn, *Chemical and Metallurgical Engineering*, Vol. 26, Page 504.

The composition of the eutectiferous carbides in high speed steel is shown to be very nearly that of the ferrotungsten added to the steel. The distribution of these carbides throughout the steel materially affect its physical properties. In the cast condition these carbide masses are irregularly distributed. Mechanical work and heat treatment will give more even distribution. Heat treatment alone will only partially accomplish this.

MALLEABLE IRON

MALLEABLIZING OF WHITE CAST IRON. By A. Phillips and E. S. Davenport. Presented at the New York Meeting of the American Institute of Mining and Metallurgical Engineers.

It is found that as the wall section of cast iron increases the graphite particles become coarser. Data is given on the critical points and some physical tests are reported. The graphitic carbon is said to be precipitated from the austenite rather than from the cementite.

METALLOGRAPHY AND HARDNESS THEORY

A NEW INDUSTRIAL METHOD OF THERMAL ANALYSIS. By M. Chevenard, *Revue de Metallurgie*, Vol. 19, Page 39.

A new critical point instrument is described which not only records differences in the cooling rate but also records dilations. Critical point curves on seven materials are included in the article.

GRAIN GROWTH AND RECRYSTALLIZATION IN METALS. II. EXPERIMENTAL DATA AND GENERAL LAWS. By Zay Jeffries and R. S. Archer, *Chemical and Metallurgical Engineering*, Vol. 26, Page 402.

The influence of time, temperature, degree of cold working, original grain size and obstructing impurities are given consideration. Strain and heat gradients are shown to have a powerful effect in grain growth.

GRAIN GROWTH AND RECRYSTALLIZATION IN METALS. III. UNDERLYING CAUSES. By Zay Jeffries and R. S. Archer, *Chemical and Metallurgical Engineering*, Vol. 26, Page 449.

The laws of grain growth are presented and the nature of grain growth force is discussed.

THEORY OF HEAT TREATMENT OF STEEL. II. By W. M. Mitchell. *Forging and Heat Treating*, Vol. 8, Page 114.

The nature and constitution of austenite, martensite, troostite and sorbite are described and the object of heat treating is outlined. The mechanism of annealing is described.

X-RAY DATA ON MARTENSITE FORMED SPONTANEOUSLY FROM AUSTENITE. By E. C. Bain, *Chemical and Metallurgical Engineering*, Vol. 26, Page 543.

The method of determining grain size by X-ray is given. It is shown that coarse grained austenite breaks up into very fine grained martensite. In this connection, ordinary etching methods are shown to be at times misleading. The evidence gained corroborates the theory of the fine grained nature of martensite.

HEAT TREATING STEEL FOR STRUCTURAL PARTS. By H. C. Knerr, *Blast Furnace and Steel Plant*, Vol. 10, Page 178.

A very general discussion is given of the influence of carbon on the metallographic and physical properties of steel, the significance of critical points and the nature of the various metallographic constituents encountered in steel. The article is primarily intended for designers and mechanics.

PHYSICAL TESTING

PHYSICAL TESTING LABORATORIES DESCRIBED. By G. F. Comstock, *Forging and Heat Treating*, Vol. 7, Page 349.

A plan view and brief description of the Titanium Alloy Mfg. Co.'s laboratory is given. The laboratory is housed in a long, narrow, well-lighted brick building.

SHOP PROBLEMS

ROLLING TEETH IN HOT GEAR BLANKS. By F. E. Walker, *American Machinist*, Vol. 56, Page 409.

Practically any type of gear, including herring-bone gears, may be produced by die rolling. The cost is considerably lower than for cut gears and the tensile strength of the rolled product is appreciably higher. Cuts of the machine are shown. Eighty to ninety gears may be produced per hour per machine.

SPECIAL FIXTURES FOR HEAT TREATING. By E. H. Tingley, *Forging and Heat Treating*, Vol. 8, Page 96.

Mechanical devices worked out in the heat treating department of the Delco Light Co. are described. These appliances are used for holding parts in cyaniding and in hardening and tempering with a view to cutting down the operating time and increasing the uniformity of the product.

DROP-FORGING PRACTICE. By J. H. Nelson, *Journal* of the Society of Automotive Engineers, Vol. 10, Page 207.

Drop-forgings which are from the chemical standpoint the same, may differ widely in physical properties. This may be due to any of the large number of variables encountered in their production. Tabular results of chemical analysis and physical properties of 107 heats of carbon steel are presented. Steels of the same grade and analyses are not found to respond to heat treatment uniformally. It is suggested that steel from the same melt be heat treated together and that more rigid inspection be instituted.

HEAT TREATING A SEWING MACHINE ROTARY SHUTTLE. By J. S. Lowe, *Forging and Heat Treating*, Vol. 8, Page 119.

The shuttle is a small thin part which it is desired to carbonize only in spots. Asbestos cement is used to prevent carbonizing where it is not desired. The shuttles are carbonized in bone charcoal and are then hardened by quenching from a cyanide bath. It is desired to temper only the point of the shuttle and this is done by means of a fine gas flame.

DISCUSSION OF FORGE FURNACES. By C. Longenecker, *Blast Furnace and Steel Plant*, Vol. 10, Page 194.

Forging furnaces are classified as (1) soaking pits (2) regenerative furnaces-large hearth area (3) non-regenerative furnaces—large hearth area and (4) furnaces of small hearth area. A brief discussion is given of each type, together with figures on the heat efficiency of each with various fuels.

POLISHING OF METALS AN ART IN ITSELF. By S. G. Koon, *Iron Age*, Vol. 109, Page 777.

The finish given a manufactured article is becoming more and more a strong sales point. Hence the importance of proper polishing. The problems encountered in polishing and grinding are outlined and some of the machinery and methods used are described and illustrated. Several typical solutions of difficult grinding problems are given.

WELDING

PRACTICAL POINTS IN ARC WELDING. By J. A. Wilson, *American Machinist*, Vol. 56, Page 357.

Attention is called to the fact that proper cleaning of fractured surfaces is essential to a successful weld. The use of a flux is not recommended. Method of correcting for expansion discussed.

ELECTRIC WELDING. By A. T. Wall, *Engineering*, Vol. 63, Page 241.

The use of electric welding in ship building has considerable possibilities. It is especially applicable in replacing riveted joints. Details of ship construction and erection are given, together with citations of the present successful use of welding in ship building.

NEW MEMBERS' ADDRESSES OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J. represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

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BONNING, F. W., (M-1), Cummings Co., Boston, Mass.
BOSTWICK, H. C., (M-3), 611 Newark Ave., Elizabeth, N. J.
BOWES, W. R., (M-1), 109 Union St., Bristol, Conn.
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JARRETT, B. L., (S-4), Oliver Bldg., Pittsburgh, Pa.
KIELMAN, J. C., (M-2), 123 Maple St., Bristol, Conn.
KRATZER, J. F., (M-4), 67 W. Northampton St., Bethlehem, Pa.
LEWIS, B. F., (M-4), 3450 Eastern Place, Detroit, Mich.
LUCAS, E. A., (M-3), Molybdenum Corporation of America, Washington, Pa.
MATHEWS, J. H. CO., (S-4), Pittsburgh, Pa., Att: H. R. Wade.
McCRUM, R. Y., (M-4), Colonial Steel Co., Pittsburgh, Pa.
McDONNELL, M. E., (M-1), Pennsylvania Railroad, Altoona, Pa.
MOLES, P. A., (A-4), Allyn House, Hartford, Conn.
MORRILLON, E. E., (M-12), 202 Miley Ave., Indianapolis, Ind.
MURDOCK, M. C., (A-3), 14115 Ardendall Ave., E. Cleveland, O.
OSTERLUND, B., (M-4), 4538 Wayne Ave., Germantown, Philadelphia, Pa.
PECK, E. C., (M-4), Cleveland Twist Drill Co., Cleveland, Ohio.
PLATT, T. H., (A-4), 299 Broadway, New York City.
RANDALL, NORMAN, (M-4), Cleveland Twist Drill Co., Cleveland, Ohio.
RICHARDSON, A. A., (M-4), 274 Farmington Ave., Hartford, Conn.
ROCKENFIELD, W. A., (M-4), 199 Chandler St., Worcester, Mass.
SLAUGHTER, E. M., (M-4), 9701 Kirkwood Ave., Cleveland, O.
SONDERMAN, W. S., (A-4), 1231 W. 9th St., Cleveland, O.
TODD, W. B., (M-4), 228 Apsley St., Germantown, Philadelphia, Pa.
UNION SWITCH & SIGNAL CO., (S-4), Swissvale, Pa. Att: A. L. Humphrey.
VERITY, M. T., (M-2), Verity Plow Co., Brantford, Ont., Can.
WARNER & SWASEY CO., (S-4), 5701 Carnegie Ave.,Cleveland, Ohio.
WEAVER, H. F., (M-4), Bethlehem Steel Co. Bethlehem, Pa.
WEITZENKORN, (M-3), Molybdenum Corporation of America, Washington, D. C.
WESTON, W. B., (A-4), 1815 Ford Bldg., Detroit, Mich.
WILLS, C. H., (M-3), Marysville, Mich.
WISE, EDMUND, (M-2), Wadsworth Watch Case Co., Dayton, Ky.
WOLCOTT, D. S., (A-4), Crucible Steel Co. of Amer., 17 E. 42nd St., New York City.

CHANGES OF ADDRESS

BARNETT, R. B.—from 221 Collins St. to 136 Whitman Ave. W. Hartford, Conn.

CASSIDY, A. G.—from 536 5th Ave. N. St. Petersburg, Fla., to 27 Banks St., Waltham, Mass.

DICKSON, T. C. JR.—from the University Club to 1001 Fairfield, Ave., Bridgeport.
DIMMICK, R. B.—from 510 Fulton Rd. to 1453 15th St., Canton, Ohio.
DOUD, C. E.—from 1422 Lunt Ave. to 7620 Sheridan Rd., Chicago, Ill.

GILHOOLY, J. H.—from 1769 Seyburn Ave., Detroit, to Tate-Jones & Co., Pittsburgh.

HARBERT, W. G.—from 207 W. Webster Ave. to 208 West Clay Ave., Muskegon, Mich.
HUMPHREYVILLE, L.—from 15420 Huntmere to 14304 Shaw Ave., Cleveland, Ohio.

KIEFER, H. G.—from 2911 Iroquois, Detroit, to 1030 Beaconsfield, Ave., Grosse Pointe Park, Mich.
KOEHLER, W. W.—from 3113 Osgood St. to Goodman Mfg. Co., Chicago, Ill.
KRAEKEMIER, HENRY—from 1647 Iranistan Ave. to 547 Pequonock St., Bridgeport.

McENTEE, P. J.—from 3 Freeman Court S. Charleston, to Ridley Park, Pa.
MACKENZIE, A.—from 1912 Western Ave. to 208 W. 8th St., Manitowoc, Wis.
MANLEY, R. S.—from 410 Perry Apts., Davenport, Ia., to 1035 17th St., Rock Island, Ill.
McINERNEY, W. I.—from 1 Curry St., Charleston, to Pittsburgh Crucible Steel Company, Midland, Pa.
MARBLE, W. H.—from 1541 Oliver Bldg. to 619 State Theater Bldg., Pittsburgh.

NEIL, E. B.—from Pierce Arrow Motor Co., Buffalo, to Harrold Motor Car Co., New York City.

OLIVER, W. O.—from 476 W. Marion St. to 308 Kennedy Rd., Toronto, Ont., Can.

PRIESTLEY, W. J.—from Quarters B. Armour Park, S. Charleston, to Pittsburgh Crucible Steel Co., Midland Wks., Midland, Pa.

PUTNAM, A. H.—from 410 Perry Apts. to 1710 E. 12th St., Davenport, Iowa.

SELLECK, T. G.—from 513 Peoples Bk. Bldg. to 302 N. Pine Ave., Chicago, Ill.
SMITH, S. G.—from 123 Sisson Ave. to 230 S. Whitney St., Hartford, Conn.

WEDLAKE, P.—from 125 Atlantic St., Anacostia, D. C., to Wilson-Maeulen Co., New York City.
WHITE, W. H.—from 3 Washington St., S. Charleston, to 307 A St. S. E., Washington, D. C.
WHITE, W. H.—from 192 Chambers St. to 56 Murray St., New York City.
WORTH, C. B.—from 501 W. Liberty St., Ann Arbor, Mich., to Wilcox Motor Parts & Mfg. Co., Saginaw, Mich.

MAIL RETURNED

CARLTON, CAPT. FRANK, 1439 Rhode Island Avenue, Washington, D. C.

EKSTROM, H. C., Dodge, Inc., S. Boston, Mass.

ETTER, P. A., 1736 Johnson Street, Philadlephia, Pa.

OTEY, N. S., 1417 Ritner Street, Philadelphia, Pa.

ROBINSON, H. A., 19 E. 88th Street, New York City.

WOOD, Edson, 315 Bay Street, Springfield, Mass.

News of the Chapters

SCHEDULE OF REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Boston—Second Friday, Franklin Union, Corner Berkley and Appleton Sts., Meeting 8:00 P. M.

Charleston—First Tuesday, Kanawah Hotel, 8 p. m.

Chicago—Second Thursday, City Club, dinner 6:30 p. m., meeting 8 p. m.

Hartford—Thursday nearest 10th of month, Jewell Hall, Y. M. C. A., 7:45 p. m.

New York—Third Wednesday, Merchants Association of New York, Woolworth Building.

Philadelphia—Last Friday, Engineers Club.

Pittsburgh—First Tuesday, Chatham Hotel, dinner 6:30 p. m., meeting 8 p. m.

Rockford—Second Monday, Nelson Hotel.

Rochester—Second Wednesday.

Schenectady—Third Tuesday, Civil Engineering Bldg., Union College.

Tri City—First Thursday following first Monday.

Washington—Second Friday.

HOW HIGH DOES YOUR CHAPTER STAND?

IN THE April issue was published the standing of the chapters as of March 1 and printed below is the standing as of April 1.

1. Chicago	11. Lehigh Valley	21. Providence
2. Detroit	12. Milwaukee	22. Schenectady
3. Philadelphia	13. North West	23. *New Haven
4. PITTSBURGH	14. WORCESTER	24. *Washington
5. *Cleveland*	15. †*Rockford*	25. Buffalo
6. New York	16. †*Cincinnati*	26. Toronto
7. *Indianapolis	17.***Tri City*	27. South Bend
8. *Hartford	18.***St. Louis*	28. Rochester
9. Syracuse	19. *Charleston*	29. Bridgeport
10. Boston	20. *Springfield*	30. Gary
* tied	† tied	* tied
	** tied	

The following explanations will be of assistance. The chapters shown in capitals have advanced their position from that occupied on March 1. Those shown in italics are not occupying as high a position as in the previous report.

It is interesting to note that Pittsburgh increased its position over that of Cleveland, due to its increased activities in securing sustaining members. Pittsburgh is not satisfied with the position it occupies at the present, and special activity is under way to continue the advancing movement.

Detroit and Chicago are in an intensive campaign for first position. Detroit has been anxious to secure the place occupied by Chicago since the organization of the Society and has excellent prospects of accomplishing its desire.

Hartford increased its membership during the month to a point where it is tied with Indianapolis for seventh place. It is possible that the report to be published in the next issue of the TRANSACTIONS will show a change in the relative positions occupied by these chapters.

Worcester made a most commendable progress during the month having advanced from 20th position to that of 14th, which of course caused the six chapters passed to lose a position and consequently to be printed in italics.

Cincinnati is tied with Rockford for 15th place, while St. Louis is tied with the Tri City for 17th and Washington is tied with New Haven for 23rd.

All of the members of all of the chapters should realize that they play an important part in the standing of their chapter and they should not place upon the Membership Committee the responsibility of advancing the chapter's position. The Society would be a decided asset and benefit to many individuals who are probably in the same plant with you or who are within your circle of acquaintanceship. All that you would need to do in order to secure their membership would be to present the Society to them in the proper manner. Your co-operation is necessary. Can they prove it by you that your chapter is asleep?

BOSTON CHAPTER

The regular monthly meeting of the chapter was held Friday evening, April 14, at 8 o'clock. The announcement of this meeting promised that the chapter would declare dividends at this meeting and it surely did. The dividends were in the form of valuable information and methods of steel inspectioin without the use of complex apparatus.

This information was very capably presented by V. O. Homerberg who has recently conducted a very successful course of instruction in metallography, given at the Franklin Union under the auspices of the Boston Chapter. Those who were fortunate enough to be able to attend this meeting surely did go away with their share of the chapters melon. It is the plan of the chapter that Mr. Homerberg will again conduct this course in metallography which is planned to start next fall.

DETROIT CHAPTER

A most interesting meeting was held in Detroit, April 10, at the Board of Commerce. About 100 were out to greet National President F. P. Gilligan, who was the guest and speaker of the evening. His talk on "What Happens to Steel When It Is Heated and Quenched", well repaid all who came out to hear it.

One of the features of the meeting was the presentation to W. C. Peterson, by President Gilligan, of a medal which was given as a token of appreciation for the faithful work he had done on behalf of the Society. For once the Detroit boys saw "Pete" at a loss to know what to say. In fact it so affected our old friend that it was not until after President Gil-

ligan had finished his main talk could "Pete" find himself, as he did, and thanked the Society in a most sincere and characteristic manner.

J. Fletcher Harper was present and gave a few words about the progress of the National Membership Committee work of which he is chairman. H. G. Giessinger on the evening of April 24 presented a very interesting paper entitled "Temperature Control". Mr. Giessinger is an expert along this line. His paper was well presented and aroused considerable discussion afterward.

PITTSBURGH CHAPTER

A joint meeting of the Pittsburgh Chapter and the Engineers' Society of Western Pennsylvania was held in the blue room, William Penn Hotel, Tuesday, April 18. The meeting opened promptly at 8 o'clock and was addressed by E. F. Collins, consulting engineer, industrial heating department, General Electric Co., who presented a paper entitled, "Some Applications of Electricity to the Reheating of Steels". The paper contained some very valuable information and discussion on metallic and nonmetallic resistor furnaces. This paper was a highly technical paper and brought out many points of information which were valuable for both engineers and heat treaters.

Mr. Collins discussed advantageous applications of the electric furnace and showed how it could be used in many industrial processes wherein steels had to be reheated either for japanning, sherardizing, enameling, or carburizing and hardening. The meeting was very well attended and proved to be highly interesting to all those who were fortunate enough in attending.

CLEVELAND CHAPTER

The Cleveland Chapter held its regular monthly meeting in the Engineering Society rooms of the Hotel Winton, Friday evening, April 28. The paper for this meeting was presented by H. A. Schwartz, director of research, National Malleable Castings Co., Cleveland. It was entitled "Some Laboratory Work on Malleable Cast Iron", and was well illustrated with stereopticon slides. Mr. Schwartz made this a practical talk from the engineers' standpoint. The meeting was well attended and many interesting points of discussion were brought out. The Nominating Committee made a report on its selection of candidates for election to office for the ensuing year. The meeting was attended by about 100 members and guests.

ROCHESTER CHAPTER

The April meeting of the Rochester Chapter was held in the Rochester Engineering Society Club rooms Wednesday evening, April 12. President F. P. Gilligan was the guest of honor and speaker for the meeting. He presented his paper entitled "What Happens to a Piece of Steel When It Is Heated and Quenched". This paper was presented in the able manner in which President Gilligan always delivers his lectures and was of great interest to the members and guests present. The discussion following this paper was especially valuable and interesting.

NEW HAVEN CHAPTER

Thursday evening, April 20, the New Haven Chapter held its monthly meeting at the Geometric Tool Co., Westville, Conn. The program for

this meeting consisted of four reels of motion pictures entitled "The Manufacture of Steel for Sheets and Plates". This picture was taken at the plant of the American Sheet & Tin Plate Co., and showed the entire working of the product from the ore to the finished plate. These pictures were obtained through the courtesy of the Bureau of Mines. The meeting was well attended and proved to be very profitable to all who were present.

SYRACUSE CHAPTER

The April meeting of the Syracuse Chapter was held in the Yates Hotel banquet room, Friday, April 7 at 7:45 p. m. W. R. Shimer, sales metallurgist, Bethlehem Steel Co., presented three reels of motion pictures of Bethlehem operations. The pictures were very interesting and brought forth numerous questions and discussions. The meeting was well attended by about 125 members and guests.

SCHENECTADY CHAPTER

The Schenectady Chapter held a meeting in the Civil Engineering building, Union College, March 21. G. R. Brophy, metallurgist, General Electric Co., gave a talk on "Metallography". The lecture was given in as plain language as was possible and was intended especially for the instruction of the practical men.

The April meeting of the Chapter was held in the Civil Engineering building, Union College, Tuesday, April 18, at 8 o'clock. This meeting was addressed by H. J. Stagg, assistant general manager of the Halcomb Steel Co., Syracuse, N. Y., who presented a paper entitled "Why Did It Break?" This paper was well illustrated with stereopticon slides. Mr. Stagg's broad experience is metallurgy and the manufacture of steel especially fits him in diagnosing the cause and remedies of many of the failures of steel parts which he showed on the screen. Many questions were asked which brought forth much valuable discussion which was of benefit to all present.

NORTH WEST CHAPTER

North West Chapter had its regular meeting at the Manufacturer's Club on Friday, April 14 when a very interesting program was given on the subject of "Forgings". The speakers were all recognized authorities on the subject and contributed to an interesting meeting.

George L. Whelan, of the Whelan Drop Forge Co., Minneapolis, was the first speaker and explained in an entertaining manner the method of making a complicated small forging used as a substitute for the hand. Mr. Whelan's broad experience with the drop forging industry, having been formerly with the Cleveland Hardware Co., especially qualified him to answer the many questions as to the relative efficiency of different types of hammers.

The second speaker was F. G. Lilygreen of the American Hoist and Derrick Co., St. Paul, who gave a description of the forging plant of that company and the general class of work it had to do as well as the various methods by which it was accomplished.

The third speaker was Melvin Ovestrud of the Twin City Forge & Foundry Co., Stillwater, who gave an interesting exposition of the various processes to produce a finished forging. Mr. Ovestrud is an authority

on forging practice and his talk proved valuable, illustrated as it was by large photographs of the installation at his plant and samples of complicated forgings.

National Secretary, W. H. Eisenman was present and talked to the members upon the work of the Society and expressed his gratification on the excellent manner in which the chapter had been conducted and the fine spirit of co-operation shown by all of the members.

SOUTH BEND CHAPTER

The South Bend Chapter had an exceptionally fine meeting on Tuesday, April 11, when O. T. Muehlemeyer of the Barber-Colman Co., Rockford, Ill., presented an interesting paper on the subject of "Hardening Room Practice". Mr. Muehlemeyer's excellent elucidation of the many difficulties involved and the best method of overcoming them, was pleasingly received. A keen and practical discussion followed the presentation of the paper.

LEHIGH VALLEY CHAPTER

John E. Halbing, assistant superintendent of heat treating, Ingersoll-Rand Co. and chairman of the Lehigh Valley Chapter, presented an interesting paper Monday evening, April 24, entitled the "Hump Method of Heat Treating". Mr. Halbing is an expert in heat treating and handled his subject in a capable and interesting manner. His talk aroused considerable interest and brought forth a good lively discussion.

In the April issue of the TRANSACTIONS it was announced that B. F. Shepherd, assistant superintendent of heat treating, Ingersoll-Rand Co., presented a paper before the Lehigh Valley Chapter, March 24, entitled "Carburizing". This paper proved to be of much interest to those who heard it, due to the fact that much of the material presented was entirely original. One of the many interesting phases of the subject as presented by Mr. Shepherd is shown in the Iron-Carbon diagram which is reproduced on the opposite page. This diagram portrays the effect of carburizing on the microstructure of steel in a very unique manner.

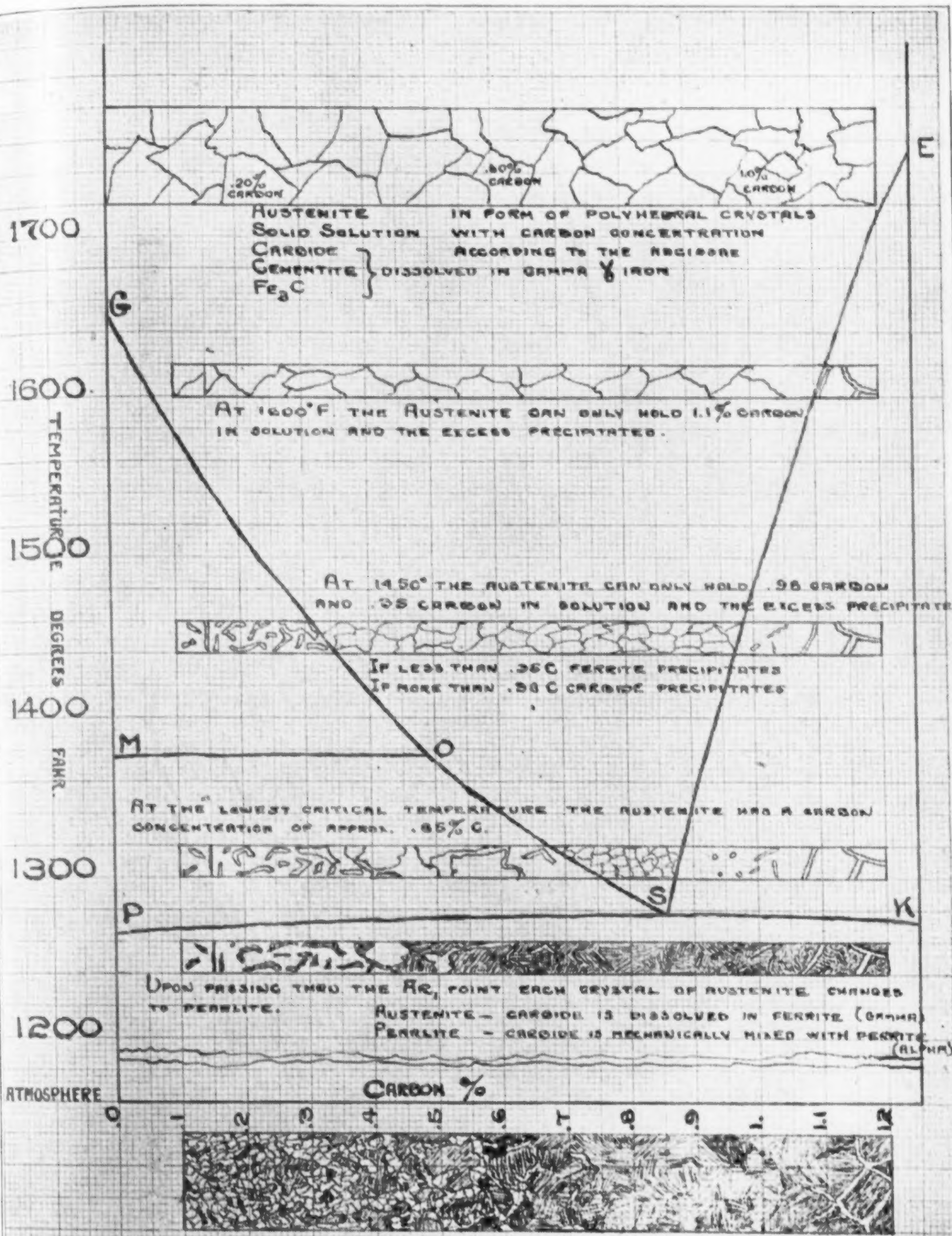
CINCINNATI CHAPTER

The regular monthly meeting of the Cincinnati Chapter was held April 20 at 8 o'clock in the Ohio Mechanics Institute. J. V. Emmons, National Treasurer and metallurgist of the Cleveland Twist Drill Co., Cleveland, presented a very interesting talk on "Tool Hardening Problems" illustrated with stereopticon slides. Mr. Emmons handled his subject capably and aroused considerable interest as evidenced by the enthusiastic discussions which followed his paper. The report of the Nominating Committee's selection of names of candidates for office for the ensuing year was made. Balloting on these names will take place at the May meeting.

CHICAGO CHAPTER

The Chicago Chapter held its regular April meeting on Thursday, April 13 at the City Club when Prof. H. F. Moore presented a paper on "Fatigue of Metals Under Repeated Stress". About 125 were present at the meeting and enjoyed Prof. Moore's presentation of the interesting subject.

National Secretary, W. H. Eisenman was present and spoke to the



Iron-Carbon Diagram Portraying Effect of Carburizing on Microstructure of Steel

membership with reference to the progress the Society had made during the past year as well as about the advance preparations for the Detroit Convention.

ST. LOUIS CHAPTER

St. Louis held its regular meeting on Friday, April 7 when O. T.

Muehlemeyer, metallurgist, Barber-Colman Co., Rockford, Ill., presented a paper on "Hardening Room Practice". Mr. Muehlemeyer presented a very interesting and practical paper dealing with the ideal method in which the day's work of tools should be handled in the hardening room. The paper contained a great deal of practical information and aroused a large amount of favorable comment and discussion. W. H. Eisenman, National Secretary, was present at the meeting and spoke to the members on matters pertaining to the Society.

INDIANAPOLIS CHAPTER

The April meeting of the Indianapolis Chapter was held Monday evening April 3 in the auditorium of the Emmerich Manual Training High School. The program for the meeting was four reels of motion pictures of processes at the National Tube Co. plants and two reels of films of the Illinois Steel Co., triplex process. Needless to say these pictures were very instructive and interesting. Following their exhibition, questions and discussions were in order. Many interesting points were covered.

RHODE ISLAND CHAPTER

The April meeting of the Rhode Island Chapter was addressed by George P. Moore, of the Wallace Barnes Co., Bristol, Conn., Wednesday, April 5. The subject of Mr. Moore's paper was the "Manufacture of Springs and Their Heat Treatment," which included the characteristics of overworked and overstrained metal. Numerous samples showing these features were displayed by the speaker. The meeting proved to be exceedingly interesting and profitable to all.

SPRINGFIELD CHAPTER

The April meeting of the chapter was held Friday, April 21, at which time Mr. De Long of the Carpenter Steel Co. gave an illustrated talk on the manufacture of steel. As this subject always brings forth many points of interest and discussion, Mr. De Long's paper brought forth its share. Following the paper an open discussion was held on the relative merits of 3½ per cent nickel steel versus chrome nickel steel for case hardening.

HARTFORD CHAPTER

The April meeting of the Hartford chapter was addressed by Dr John A. Mathews, president of the Crucible Steel Co. of America. His subject was "Iron in Antiquity and Today", and consisted of a complete and interesting history of the development and use of iron and steel from prehistoric ages up to the present time. The talk was illustrated by slides taken from ancient books, showing the methods and devices for fabricating steel in the olden days. The audience numbered 110, of which about half were members.

Before the meeting, an impromptu dinner was held at the Hotel Bond, at which were present representative executives from the different industries of Hartford and Bristol, who had been invited to meet Dr. Mathews in this way, also the members of the Gauge Steel Committee, who had met with him and Chairman Blood in the afternoon.

Plans for increasing the membership of the chapter were discussed at the meeting, and a standards committee and a nominating committee appointed. The question of relative excellence of acid and basic open-

hearth steel was brought up and discussed. Mr. Blackman, of Colt's Patent Firearms Mfg. Co., also asked for the experience of others in producing file hardness in a 0.45 carbon, 3.50 nickel, 1.50 per cent chrome steel. It appeared the general opinion that file hardness could not be obtained in a steel of this type, unless case hardening was resorted to. This treatment was not favored by those present.

The spring inspection meeting was held Saturday, April 29. A complete report of this meeting will appear in the June issue of the TRANSACTIONS.

TRI CITY CHAPTER

The Tri City Chapter of the society held its regular monthly meeting March 29 in the rooms of the Davenport Chamber of Commerce. A. H. Putnam, chairman appointed the members of the nominating committee for the nomination of candidates for the ensuing year.

Prof. John F. Keller of the Lewis Institute presented a talk on "Why Steel Warps", going into details on both the heating and cooling of steels. He gave a practical demonstration of the decalescent and recalescent point with an electrically-heated wire. This paper was followed by a discussion of practical heat treating problems after which Prof. Keller was given a rising vote of thanks.

The Tri City chapter held its April meeting, Thursday the 27th. C. W. Veach, superintendent of the open-hearth furnaces of the Bettendorf Steel Car Co., presented a very interesting paper entitled "Reactions in the Open-Hearth Furnace." This paper proved to be exceedingly interesting and was followed by a large amount of good discussion. The meeting was preceded by a get together dinner which was served at 7 p. m.

NEW YORK CHAPTER

The New York chapter regular April meeting was held in the assembly room of the Merchants Association of New York, 9th floor of the Woolworth Building, Tuesday, April 25. Through a joint arrangement with other eastern chapters of the Society, Prof. H. F. Moore of the Engineering Experimental Station of the University of Illinois was secured as the speaker of the evening and presented his paper entitled the "Fatigue of Metals." Professor Moore has specialized extensively in the study of fatigue resisting values of various steels and his paper proved to be of great interest to all as evidenced by the discussion which followed his paper.

Reviews of Recent Patents

Arthur E. Bellis, Springfield, Mass., recommends that metal be heated in a salt bath prior to forging, rolling or other hot work. Accurate temperature control is possible, and when withdrawn the metal is covered with a thin film of salt which prevents surface oxidation and helps to avoid uneven chilling by variable air currents. In this manner scaling is reduced to a great extent and trouble and expense consequent to oxidation are avoided. (1,399,044. Dec. 6, 1921.)

1,404,438. Heat insulating and resisting material. Edgar T. Holmberg, Cleveland, Ohio, assignor to The James H. Herron Co., Cleveland, Ohio.

A heat insulating and resisting material of about 30 per cent of magnesia and 70 per cent of an infusorial siliceous earth with a saturated solution of magnesium chloride.

1,402,722. Apparatus for the heat treatment of metals. Lyman C. Josephs, Jr., Allentown, Pa., and Gottfried Wirrer, Plainfield, N. J., assignors to International Motor Company, New York, N. Y.

In an apparatus for the heat treatment of metal, the combination of means to effect a change in the heat treatment and devices subject to a reduction in the rate of expansion of the metal under treatment whereby the actuation of said means is initiated.

1,401,983. Method of heat treatment and furnace therefor, Axel Gustaf Emanuel Hultgren, Gottenborg, Sweden, assignor to Aktiebolaget Svenska Kullagerfabriken, Gottenborg, Sweden.

The method of heat treatment of symmetrical circular objects constituting solids of revolution, which consists in passing them in a continuous succession through a long chamber in which they are directly exposed, the bottom of which chamber has such inclination that the objects advance with a rolling traction on the bottom while sliding against one another at their points of tangential contact, simultaneously heating such chamber, and controlling the progress of the objects through the chamber at such rate with reference to their mass and to the temperature and length of the chamber as to subject each of the successive objects during its rolling progression to the prescribed heat treatment.

1,403,313. Combination double-muffle preheating and heat treating furnace. James A. Gaskill, Cleveland, O.

A heat treating furnace comprising a combustion chamber, a cover having a central opening, an annular air compression chamber, a tangentially placed inlet pipe for air at the base of said air chamber, tangential fuel burner, nozzles discharging in said combustion chamber, a mixing chamber for fuel and air communicating with each burner nozzle, air passages leading from air chamber and communicating with mixing chambers and a muffle horizontally supported in combustion chamber, muffle extending through the walls of combustion chamber and air chamber, and a door in the outer wall of air chamber giving access to muffle.

Commercial Items of Interest

A MINING engineer and a metallurgist are to be selected by the Bureau of Mines and by the Bureau of Standards in the near future to make an intensive study as to present practice in the heat treatment of drill steels and the extent to which breakage occurs. These engineers are to make a much more exhaustive survey than ever has been attempted before. They will submit a report to the advisory board which is co-operating with the bureaus in the study of rock drill steels and other steels which must withstand impact stresses. The advisory committee is composed of B. F. Tilson, H. S. Brainard, J. A. Mathews, George H. Clark, H. M. Boylston, Van H. Manning, F. W. Deonton, Walcott Remington and Bradley Stoughton. The survey about to be undertaken is under the immediate supervision of D. A. Lyon, chief metallurgist of the Bureau of Mines, and G. K. Burgess, of the Bureau of Standards.

AN electrically operated blast, intended for heat treating and other furnaces has been placed on the market by the Clements Mfg. Co., 601 Fulton street, Chicago. Among the advantages claimed are that as the blast is operated from an electric light socket, it may be used while the rest of the plant is shut down. It is designed to draw a sufficient quantity of gas from the mains to develop heating effects without variation. A feature emphasized by the makers is the saving from the speed at which the furnace is brought up to the desired temperature, it being said that the furnace may be brought up to 1600 degrees Fahr. in a few minutes.

The blast is driven by a 1/6-horsepower universal motor and is designed so as to be able to deliver 210 cubic feet of air per minute at the normal operating speed of motor. A damper for regulating the mixture of air and gas has been incorporated. The operation is similar to that of a carburetor on an automobile. The mixture should be rich at first and continue so until the furnace is warmed up, the damper being opened gradually to admit air.

The Chicago branch of the Driver-Harris Co., manufacturers of nichrome heat treating containers, has taken enlarged quarters and will be located in them after May 1. These new quarters are at 562-574 West Randolph street.

A series of tests was completed recently by the Bureau of Standards, Washington, on samples of electric and open-hearth heats of silicomanganese spring steels carrying equal proportions of carbon, manganese, phosphorus, sulphur and silicon. The tests included microscopic examination, tensile strength, and determination of proportions of certain gases present, particularly nitrogen and hydrogen. In general, the microstructure of the electric steel was somewhat different from that observed in the open-hearth when both steels were subjected to the same heat treat-

(*Continued on Page 34*)

EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice.

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITION WANTED

METALLURGIST or SUPT. HEAT TREATING—Technical graduate University of Illinois. Experience in heat treating and annealing forgings and castings all sizes up to 50 tons; production study and estimating; metallurgy, metallography, chemical analysis; physical testing and final inspection; installation and maintenance various makes pyrometers; research and investigation; three years superintendent heat treating. Age 30. Address 4-12.

METALLURGIST—or Supt. of Heat Treating with 12 years experience, 10 of which have been as executive in charge of laboratories and supervisor of metallurgical operations in Steel Works and industrial plants. Broad experience in chemical, physical and metallographical testing and the heat treatment of automobile and other alloy steels. Location desired East of Pittsburg, age 30, married. Address 4-7

SUPERVISOR HEAT TREATING. Chemical, Metallurgical Metallographical Laboratory large Motor Truck Company. 12 years experience. Formerly with U. S. Steel Corporation, U. S. Government Engineer of Tests & Metallurgist, also foundry experience in malleable, gray iron, steel, semi-steel. Age 35. American. Married. Eastern location preferred. Wages desired $200.00 per month. Answer 3-25.

FOREMAN OR INSTRUCTOR—Nine years instructor forge work, College Cornell University; four years foreman toolsmith and steel treater of large ship-building corporation. Thoroughly experienced in all classes of steel. Wages reasonable. Location preferred, Ohio, Massachusetts, New York, Pennsylvania, and Connecticut. 2-5

ENGINEERING or PRODUCTION WORK—Technical Graduate. 2 years heat treatment of armor plate, guns, etc. 2 years charge heat treatment auto parts. 2 years charge commercial heat treating shop. At present employed as equipment sales agent. Desire to make change to engineering or production work. Salary desired $200-$250. per month. Address 5-25.

SALESMAN—Graduate University of Pittsburgh. 3 years chemist. 3½ years chemist and metallurgist. 3½ metallurgist and chief inspector. Experience in all departments of mill work, rods, wire, plates, spikes, etc. Familiar with nearly all classes of steels including alloys. Location preferred Pittsburgh. Address 5-30.

METALLURGIST—10 years experience in carburizing and heat treatment of carbon, alloy and tool steels. Extensive experience in physical testing, metallography, pyrometry and metallurgical research. Also experienced in handling large forces of men. Have had as many as 600 men under my supervision. Eastern location preferred. Salary desired $4500. per year. Address 5-35.

CHEMIST OR HEAT TREATER—Technical graduate. Experience in chemical and physical testing, heat treating of steels, platinum metals and rare earths. Best of references. Reasonable salary. Address 3-15.

ASSISTANT METALLURGIST—4½ years experience in U. S. Armories, 4 years laboratories brass rolling mill and shell factory. Experience included installation and maintenance pyrometers, research work, micro examinations and microphotography, critical temperature measurements and carburizing and heat treatment of small parts. Willing to consider any position in metallurgical department, annealing or heat treating department providing there is opportunity for advancement. Wages desired $150.00 per month. Location preferred Rhode Island, Massachusetts, or Connecticut. Address 5-15.

METALLURGIST AND ENGINEER—Experience in purchasing, production, layout, forge shop, heat treating, laboratory and research work. Capable of taking entire charge of malleable, gray iron, semi steel or steel foundry. Desires employment with progressive firm. Address 5-41.

FURNACE DESIGNER and BUILDER—Steel treating furnaces or to take charge of furnace construction and repairs in steel treating department of large manufacturing plant. A number of years experience designing, building and operating furnaces of all types for all classes of work including mechanical and automatic furnaces for heat-treating, carbonizing, and annealing. Willing to make part of compensation dependent upon ability to improve quality of work and reduce costs. Location immaterial. Address 5-5.

CHEMIST—Metallurgist, metallographist, physical tester or heat treater. 12 years experience. Former Government metallurgist. Now an executive with large motor truck company. Also malleable and semi steel foundry experience. Can organize and manage men. No location preferred. Address 5-10.

CHEMIST OR ASSISTANT TO CHIEF METALLURGIST: Technically trained. Practically experienced in chemical and physical analysis, pyrometry general heat treating, foundry control, shop work and methods. Able to investigate trouble and handle same. Michigan or adjacent territory preferred. Answer 3-20.

TOOL HARDENER OR FOREMAN—30 years earnest effort in tool forging and tool hardening with extensive high speed steel experience. Can offer efficient operation or supervision. Exceptionally successful in eliminating scrap—Excellent references. Location immaterial, wages desired $50.00 per week. Address 3-40

SALES ENGINEER—Thorough metallurgical training and experienced salesman. At present employed but desires change. Wide acquaintance New York, New England and Canada. Basic knowledge foreign markets and can produce. Age 28. Married. Address 4-5.

METALLURGIST—Eight years experience in research, metallography, heat treatment, complaint and service work; High speed, tool steel and cast cutter work. Address 3-30

CHEMIST OR HEAT TREATER—Technical graduate. Experience in chemical and physical testing, heat treating of steels, platinum metals and rare earths. Best of references. Reasonable salary. Address 12-10.

CHEMIST-METALLURGIST—Experienced in making steel castings, all processes. Am a practical foundry man, steel blower, and chill roll maker. Have been Supt. of large foundry. Best of References. Age 40. Married. Address 3-2.

METALLURGIST OR CHEMIST—Graduate of Ohio State. Extensive experience covering heat treatment, case hardening, pyrometry, chemical analysis, metallography, and investigation of tool troubles. Best of recommendations. No preference as to location. Address: 4-50.

Was connected with United States Naval Ordnance Plant having charge of metallography and heat treatment the past two years, has had practical electric melting experience. Best of recommendations. No restrictions of location. Address 4-35.

HEAT TREATING DEPARTMENT—Technical graduate. Hardening room automobile firm. Experienced on aluminum castings. Die Superintendent and metallurgist for steel tool company. Salary $150.00. Cleveland location preferred. Address 4-10.

FOREMAN HEAT TREATMENT—16 Years experience on armor plate gun forgings and all kinds of heavy forgings and castings; carburizing, research, testing and experimental work including design operation and erection of all types of heat treating furnaces. Age 32. Married. Address 3-5.

STEEL EXPERT—Heat treatment, metallurgy. A graduate in chemistry and iron and steel manufacture. Six years laboratory experience. Desire position in production department. Can make good. Present salary ($3000.00) Ordnance man, Navy Department. Will consider ($2000.00) as a start if there are good prospects. Address 3-10

SUPERVISOR HEAT TREATING—Or assistant. Ten years experience as chemist on iron and steel. One year practical experience on metallurgical inspection directly connected with heat treatment. Have made a study of the subject. No preference as to location. Wages $40.00 per week desired. Answer 5-50.

POSITIONS OPEN

WANTED—Young college graduate with one or two years practical experience in physical metallurgy to carry out physical tests and micro examination with a government bureau. Entrance salary $1800 per annum. Position offers excellent opportunity to become familiar with certain phases of physical metallurgy of great practical value. Address 4-32.

COMMERCIAL HEAT TREATING PLANT—A young man not afraid of work who is willing to give his best efforts so that he can advance in confidence of the employer and ultimately attain a position of responsibility. Experience desirable, but not necessary. Plant located in Cleveland. Address 4-50

ADVERTISING SOLICITOR—A well known publication desires an experienced steel salesman to solicit specialized advertising. Salary and commission. Headquarters will be in New York, but unlimited as to territory. Experienced in soliciting advertising not necessary. Address 4-60

STEEL SALESMAN—To cover Northern Ohio. Must have had selling experience and thoroughly familiar with high speed and carbon tool steels. An excellent opening for someone who can produce results. Address 3-10.

A well known steel firm desires tool steel salesman to work out of Cleveland office. Would consider only a thoroughly experienced man. Address 4-44.

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ment. It is more or less generally recognized that steels of the same composition, in so far as the elements used are concerned, require variations in heat treatment to produce similar properties. This applies to comparisons between heats made by the same type of process and steels produced by different processes.

Under certain thermal treatments, distinct differences in tensile properties were observed, but these were obliterated largely by a preliminary normalizing quench from a high temperature. It was found that the proportion of oxygen present in these steels was practically the same, about 0.028 per cent, and independent of the heat treatment applied. The nitrogen in the original rolled samples of electric steel was approximately twice that of the open-hearth and independent of the heat treatment. In the case of the electric steel, however, the proportions of nitrogen were dependent upon the heat treatment.

W. P. Paul has been appointed eastern district representative of the General Drop Forge Co., Inc., Buffalo. He will have charge of the company's offices in the Woolworth building, New York, and in the Drexel building, Philadelphia.

In response to a request for information as to the proper iron analysis for withstanding the frequent alternate heating and cooling to which domestic heating furnaces are subjected, the *Iron Age* reports that Y. A. Dyer, Birmingham, Ala., has suggested the following:

Percentage of	Heavy	Medium	Light
Silicon	1.75	2.00	2.25
Sulphur	0.08	0.06	0.06
Phosphorus	0.30	0.40	0.50
Manganese	0.90	0.70	0.60
Total Carbon	3.30	3.40	3.45

Bradley Stoughton, formerly secretary of the American Institute of Mining and Metallurgical Engineers, was elected president of the Yale Engineering Association at the annual meeting of the organization on Feb. 2.

C. R. Sabin has been appointed manager of the Cleveland Engineering Society, Cleveland, to fill the vacancy caused by the resignation of George S. Black. Since his graduation from the department of civil engineers of the University of Michigan in 1918, Mr. Sabin has been engaged in civil engineering and construction work.

A pronounced feeling exists in engineering circles in Washington that the proposed Engineering Congress to be held in connection with the Philadelphia Sesquicentennial should be promoted in a national and international way, and that this can be done best by the Federated American Engineering Societies. Local promotion of the congress would be handicapped, it is believed, by the assumption that Philadelphia engineers naturally would be inclined by the incidental benefits to their city to represent such a gathering as certain to be a momentous occasion. If the arrangements were handled by the national

machinery, which the organizations in many branches of engineering have set up, it is believed a different impression will be created.

At a recent meeting of the Philadelphia section of the American Chemical Society, a national meeting of the society in Philadelphia during the Sesquicentennial Exposition in 1926 was urged.

The names of the following, who are proposed for membership in the Iron and Steel Institute, appear in the voting list for the annual meeting in London, May 4 and 5: Reynolds C. Baldwin, Stanley Rule & Level Co., New Britain, Conn.; Louis J. Campbell, Electric Alloy Steel Co., Youngstown, O.; Henry J. Freyn, 645 People's Gas Building, Chicago; Marcus A. Grossman, Electric Alloy Steel Co., Charleroi, Pa.; J. Fletcher Harper, 291 Thirty-third Street, Milwaukee; Russell C. Heaslett, Wheeling Mold & Foundry Co., Wheeling W. Va.; Herman A. Holz, 17 Madison Avenue, New York; D. P. Hopkins, United Cast Iron Pipe & Foundry Co., Philadelphia; Ralph Seymour Poister, United Alloy Steel Corp., Canton, O.; Oscar Lee Pringle, Pittsburgh Crucible Steel Co., Midland, Pa.

Thomas Towne, formerly vice president and general manager of the Federal Tool & Alloy Steel Corp., 66 Rutledge Street, Brooklyn, has been succeeded by V. H. Todd as general manager and Edward Munson as vice president.

The Ithaca, N. Y., office of the Bureau of Mines is continuing the study of special series of molybdenum and cerium steels. Endurance tests with special regard to the effects of inclusions on endurance have recently been made. The final report on cerium has been made by Dr. H. W. Gillett to the Welsbach Co., which is the chief cerium producer and which co-operated in this work, being interested in finding new applications for this metal.

A new shape of test bar has been adopted which seems better suited to endurance testing, and over 200 test bars were prepared and sent out for machining. Metallographic study of inclusions and other causes of fatigue failure has been continued on bars prepared by the Bureau of Mines, and on some obtained from the University of Illinois and the United States Naval Experiment Station.

William J. Priestley, formerly steel superintendent naval ordnance plant, South Charleston, W. Va., has been appointed works manager, Pittsburgh Crucible Steel Co., Midland, Pa., succeeding H. P. Barnard, resigned, and has assumed his new duties. Prior to going to the naval ordnance plant, Mr. Priestley was a division superintendent at the Lehigh plant of the Bethlehem Steel Co. He was graduated from Lehigh University, class of 1908.

Electric heat treating is far from a novelty at the plant of the National Malleable Castings Co. In 1922 the same furnaces will be in continuous operation which have been in constant service since 1914—perhaps the oldest installation of electric furnaces for this purpose in the country, and certainly the greatest installation in point of tonnages handled, according to *Forging and Heat Treating*. Each unit consists of a set of two furnaces. Rated at 900 kilowatts in electrical capacity, they have a tonnage capacity of three

tons of draw bar knuckles per hour. There are two of these sets at present in active operation in the plant. In addition, the chain annealing furnaces, which were located at Cleveland during the war time for serving the Emergency Fleet corporation, have been moved to Sharon and are at work annealing commercial chain.

The development of the particular equipment mentioned was undertaken by the Electric Furnace Construction Co., with the understanding that an apparatus should be furnished that would, in so far as possible, eliminate the human element throughout the entire heat treating operation. One of the conditions laid down was that the control instruments should be set for a special treatment, and that no material could get through unless it had that precise treatment. The limitations in temperature variation in the instance were not to exceed 5 degrees Fahr. above or below a designated temperature in the hardening and drawing operations, and no greater variation than 20 degrees Fahr. in the temperature of the material as it came from the quenching bath. All of these conditions were met in the test of the equipment, and have been met daily over seven years continuous operation, with the exception of such periods, during industrial depression, when the plant was not in full operation.

The annual business meeting of the American Iron and Steel institute will be held at the principal office Room 504, the Barrett building, New York city, May 1, at 12 o'clock noon. The principal item of business to be considered will be the election of seven directors to serve for the next three years. This business meeting is distinct from the general meeting of the institute which will be held as usual on the fourth Friday in May.

The joint committee on the investigation of the effect of phosphorus and sulphur in steel, which is composed of representatives of a number of the leading technical societies including the American Society for Testing Materials, the American Society of Mechanical Engineers and the Society of Automotive Engineers, has issued a progress report. Copies of this report, which covers the activities of the committee for the past 2 years, can be obtained from C. L. Warwick, its chairman, 1315 Spruce street, Philadelphia, or from the Bureau of Standards, City of Washington. It is expected that all of this material will be published ultimately by the Bureau of Standards.